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Victoria County

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By Geomatics International Limited and D.J. Rowell

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Contents

Abstract v

Introduction 3

Part I - Inventory Methods 4
- Field and Office Methods 4
- Resource Tonnage Calculation Techniques 4
  - Sand and Gravel Resources 4
  - Bedrock Resources 5
  - Units and Definitions 5

Part II - Data Presentation and Interpretation 6
- Map 1: Sand and Gravel Resources 6
  - Deposit Symbol 6
  - Texture Symbol 6
- Selected Sand and Gravel Resource Areas 6
  - Site Specific Criteria 7
    - Deposit Size 7
    - Aggregate Quality 7
    - Location and Setting 8
  - Regional Considerations 8
- Map 2: Bedrock Resources 8
  - Selection Criteria 9
  - Selected Resource Areas 9

Part III - Assessment of Aggregate Resources in Victoria County 10
- Location and Population 10
- Surficial Geology and Physiography 10
- Extractive Activity 12
- Selected Sand and Gravel Resource Areas 12
  - Selected Sand and Gravel Resource Area 1 13
  - Selected Sand and Gravel Resource Area 2 14
  - Selected Sand and Gravel Resource Area 3 14
  - Selected Sand and Gravel Resource Area 4 14
  - Selected Sand and Gravel Resource Area 5 15
  - Selected Sand and Gravel Resource Area 6 15
  - Selected Sand and Gravel Resource Area 7 15
  - Selected Sand and Gravel Resource Area 8 15
  - Selected Sand and Gravel Resource Area 9 15
  - Selected Sand and Gravel Resource Area 10 16
  - Selected Sand and Gravel Resource Area 11 16
  - Selected Sand and Gravel Resource Area 12 16
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  - Selected Sand and Gravel Resource Area 17 17
  - Selected Sand and Gravel Resource Area 18 18
  - Selected Sand and Gravel Resource Area 19 18
  - Selected Sand and Gravel Resource Area 20 18
  - Selected Sand and Gravel Resource Area 21 18
  - Selected Sand and Gravel Resource Area 22 19

Selected Sand and Gravel Resource Area 23 19
Selected Sand and Gravel Resource Area 24 19
Sand and Gravel Resource Areas of Secondary Significance 20
Bedrock Geology and Resource Potential 22
Selected Bedrock Resource Areas 24
Selected Bedrock Resource Area 1 25
Selected Bedrock Resource Area 2 25
Summary 27
References 62
Metric Conversion Table 81
Appendix A – Suggested Additional Reading 64
Appendix B – Glossary 66
Appendix C – Geology of Sand and Gravel Deposits 69
Appendix D – Geology of Bedrock Deposits 71
Appendix E – Aggregate Quality Test Specifications 79

FIGURES

1. Key Map Showing the Location of Victoria County v
2. Precambrian geology of northern Victoria County 23
3A–5B Aggregate Grading Curves – Victoria County 56
D1 Bedrock Geology of Southern Ontario 77
D2 Exposed Paleozoic Stratigraphic Sequences in Southern Ontario 78

TABLES

1. Total Sand and Gravel Resources – Victoria County 28
2. Sand and Gravel Pits – Victoria County 33
3. Selected Sand and Gravel Resource Areas – Victoria County 43
4. Total Identified Bedrock Resources – Victoria County 45
5. Quarries – Victoria County 49
6. Selected Bedrock Resource Areas – Victoria County 51
7. Summary of Test Hole Data – Victoria County 54
8. Summary of Geophysical Data – Victoria County 54
9. Results of Aggregate Quality Tests – Victoria County 55
E1 Selected Quality Requirements for Major Aggregate Products 80

GEOLOGICAL MAPS (back pocket)

1. Sand and Gravel Resources, Victoria County, Scale 1:50 000, Maps 1A and 1B.
2. Bedrock Resources, Victoria County, Scale 1:50 000, Maps 2A and 2B

CHARTS

Chart A – Area and Population 10
Chart B – Summary of Extractive Activity 13
Chart C – Bedrock Resources Summary 26

Abstract

This report includes an inventory and evaluation of sand and gravel and bedrock resources for Victoria County. This report is based on previously published Aggregate Resource Inventory reports, other previously published studies and field work undertaken in the spring of 1995. The investigation was conducted to delineate and determine the quality and quantity of aggregate within the area to help ensure that sufficient aggregate resources are available for future use. The report is part of the Aggregate Resources Inventory Program for areas designated under the *Aggregate Resources Act* (ARA) 1989.

Large ice-contact, subaqueous fan and esker-kame deposits contain the best sand and gravel resources in Victoria County. In southern Manvers Township, the Oak Ridges Moraine provides aggregate to the Greater Toronto Area (GTA). The rest of the deposits in the county are generally capable of meeting local demands. The exception to this is in the extreme northern part of the county where sand and gravel deposits are limited by size, quality and access. This report identifies 24 Selected Sand and Gravel Resource Areas for possible resource protection. The selected resource areas occupy 5811 ha with a possible sand and gravel resource of 747.5 million tonnes.

Significant bedrock resources are available in the northern half of Victoria County. The 2 Selected Bedrock Resource Areas identified in this report consist of those areas of the Gull River and Bobcaygeon formations that are overlain by less than 8 m of overburden. The crushed limestone from these units is suitable for a wide range of aggregate, however, the Ministry of Transportation may not accept some crushed stone for use in concrete aggregate because of the possible presence of alkali-reactive beds. The 2 Selected Bedrock Resource Areas occupy a possible resource area of 50 747 ha with a possible bedrock resource of 24 199 million tonnes.

Selected Resource Areas are not intended to be permanent, single land use units that must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

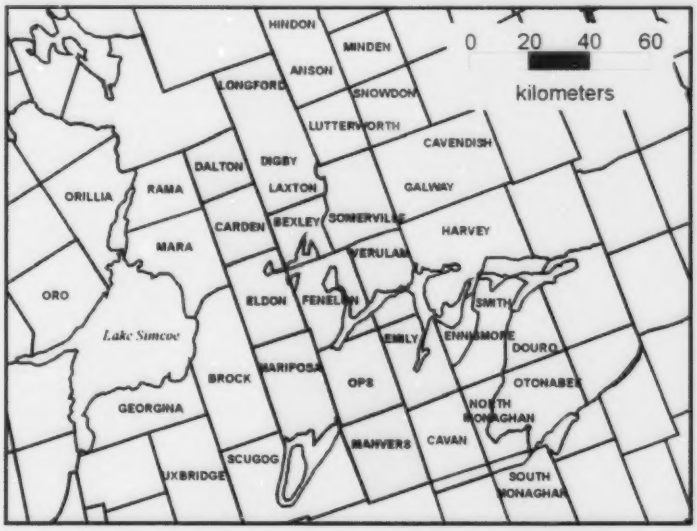

Figure 1. Key map showing the location of Victoria County.

Aggregate Resources Inventory of Victoria County

By Geomatics International Limited and D.J. Rowell

Project Supervisor: C.L. Baker. Initial compilation and drafting by staff of Geomatics International Limited. Final compilation by D.J. Rowell of the Ontario Geological Survey. Assistance with review provided by the Resident Geologist, Ministry of Northern Development and Mines, Tweed, Ontario; the Soils and Aggregates Section, Ontario Ministry of Transportation, Downsview, Ontario; and the Mineral Resources Staff, Peterborough and Minden Area Offices, Ministry of Natural Resources.

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Introduction

Although mineral aggregate deposits are plentiful in Ontario, they are fixed–location nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in many areas, especially urban areas where demand is the greatest.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Unfortunately, in some cases, the best aggregate resources are found in or near areas of environmental sensitivity, resulting in the requirement to balance the need for the different natural resources. Therefore, planning strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory Program is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision–makers in protecting the public well–being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of an area's resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential for bedrock–derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Part I – Inventory Methods

FIELD AND OFFICE METHODS

This report provides a consolidation of the previously released Aggregate Resource Inventory Reports for Victoria County (Ontario Geological Survey 1980 a–f, 1981a, 1981b, 1981c, 1992a, 1992b). The contents of existing reports were reviewed in detail. All of the resource areas of primary significance and some of the resource areas of secondary significance that had been originally outlined were field checked. As necessary, field samples were collected and were tested for gradation and petrographically analysed. Data was also collected from the Ontario Ministry of Transportation (MTO) files and from testing companies involved in licencing procedures under the *Aggregate Resources Act*, 1989. The collected information was compiled, analysed and incorporated with the data found within the existing Aggregate Resource Inventory Reports.

All previously Selected Sand and Gravel Resource Areas of primary and secondary significance were examined considering the following: 1) licencing that has occurred since the original inventory was conducted; 2) discussions with the appropriate staff of the Ministry of Natural Resources; 3) review of available public and private research reports; 4) reports prepared for licencing purposes; and 5) personal knowledge of the staff involved in completion of the project. This report provides a consolidation of the previously released Aggregate Resource Inventory Reports.

Field methods included the examination of natural and man–made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation (MTO), the Ontario Geological Survey (OGS), and by Regional, District and Area Offices of the Ontario Ministry of Natural Resources (MNR). Observations made at pit sites included estimates of the total face height and the proportion of gravel– and sand–sized materials in the deposit. Observations regarding the shape and lithology of the particles were also made. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, subsurface materials may be assessed by hand augering and test pitting.

Deposits with potential for further extractive development or those where existing data are scarce were studied in greater detail. Representative sections in these deposits were evaluated by taking 11 to 45 kg samples from existing pit faces or from test pits. The samples were tested for grain size distribution; in some cases the Los Angeles abrasion and impact test, absorption, Magnesium Sulphate soundness test and petrographic analyses were conducted on the samples. Analyses were performed in the laboratories of the Ontario Ministry of Transportation.

The field data were supplemented by pit information on file with the Geotechnical Section of the Ontario Ministry of Transportation. Data contained in these files includes field estimates of the depth, composition and "workability" of deposits, as well as laboratory analyses of the physical properties and suitability of the aggregate. Information concerning the development history of the pit and acceptable uses of the aggregate is also recorded. The locations of additional sources were obtained from records held by Regional, District and Area Offices of the Ontario Ministry of Natural Resources. In addition, reports on geological testing for type, quantity and quality of aggregates were also obtained from numerous aggregate licence applications on file with the MNR and with specific individuals and companies. The cooperation of the above–named groups in the compilation of inventory data is gratefully acknowledged.

Aerial photographs at various scales were used to determine the continuity of deposits, especially in areas where information was limited. Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate deposit thickness estimates or to indicate the presence of buried granular material. These records were used in conjunction with other evidence.

Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a base map, also at a scale of 1:50 000. These base maps were prepared with information taken from maps of the National Topographic System by permission of Natural Resources Canada, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

Sand and Gravel Resources

Once the interpretative boundaries of the aggregate units have been established, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in hectares (ha). The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well records. Tonnage values can then be calculated by multiplying the volume of the deposit by 17 700 (the density factor). This factor is approximately the number of tonnes in a 1 m thick layer of sand and gravel, 1 ha in extent, assuming an average density of 1770 kg/m^3.

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e., original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of hectares unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g., wayside, unlicenced and abandoned pits are included in this category). The remaining figure is the area of the deposit potentially available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 17 700), to give an estimate of the sand and gravel tonnage (Column 7) potentially available for extractive development and/or resource protection. It should be noted, however, that recent studies (Planning Initiatives Limited 1993) have shown that anywhere from 15 to 80% of the resources in an area may be further constrained or not accessible because of such things as environmental considerations (e.g., floodplains, environmentally sensitive areas), lack of landowner interest, resident opposition or other matters.

Resource estimates are calculated for deposits of primary significance. Resource estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however, the aggregate potential of these deposits is discussed in the report.

Bedrock Resources

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 15 m of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps, and from the interpretation of water well records (Table 4). The measured extent of such areas is then multiplied by the estimated quarriable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of 18 m is used for thickness. Volume estimates are then multiplied by the density factor (the estimated weight in tonnes of a 1 m thick section of rock, 1 ha in extent).

Resources of limestone and dolostone are calculated using a density factor of 2649 kg/m^3, sandstone resources are calculated using a density estimate of 2344 kg/m^3, and shale resources are calculated with a factor of 2408 kg/m^3 (Telford, Geldart, Sheriff and Keys 1980).

Units and Definitions

The measurements and other primary data available for resource tonnage calculations are given in Metric units in the text and on the tables which accompany the report. Data are generally rounded off in accordance with the Ontario Metric Practices Guide (Ontario Interministerial Committee on National Standards and Specifications 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources (see Glossary, Appendix B) in accordance with terminology used by the Ontario Resource Classification Scheme (Robertson 1975, p.7) and the Association of Professional Engineers of Ontario (1976).

Part II – Data Presentation and Interpretation

Two maps, each portraying a different aspect of the aggregate resources in the report area, accompany the report. Map 1, "Sand and Gravel Resources", gives a comprehensive inventory and evaluation of the sand and gravel resources in the report area. Map 2, "Bedrock Resources", shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments and identifies the Selected Bedrock Resource Areas.

MAP 1: SAND AND GRAVEL RESOURCES

Map 1 shows the extent and quality of sand and gravel deposits within the study area and an evaluation of the aggregate resources. The map is derived from existing surficial geology maps of the area or from aerial photograph interpretation in areas where surficial mapping is incomplete.

The present level of extractive activity is also indicated on Map 1. Those areas which are licenced for extraction under the *Aggregate Resources Act* are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner/operator and licenced hectarage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or pits operating on demand under authority of a wayside permit) are identified by a numbered dot on Map 1 and described in Table 2. Similarly, test hole locations appear on Map 1 as a point symbol and are described in Table 7.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

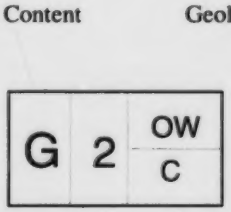
Deposit Symbol

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type) and quality limitations for every deposit shown on Map 1.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35% of the whole deposit. "G" indicates that the deposit contains more than 35% gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C), and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.



For example, the above symbol identifies an outwash deposit 3 to 6 m thick containing more than 35% gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

Texture Symbol

The Texture Symbol provides a more detailed assessment of the grain size distribution of material sampled during field study. These symbols are derived from the information plotted on the aggregate grading curves found in the report. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically in the Texture Symbol by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30% gravel, 60% sand and 10% silt and clay.

SELECTED SAND AND GRAVEL RESOURCE AREAS

All the Selected Sand and Gravel Resource Areas are first delineated by geological boundaries and then classified into 3 levels of significance: primary, secondary and tertiary. Each area of primary significance is given a deposit number and all such deposits are shown by red shading on Map 1.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units. They represent areas in which a major resource is known to exist, and may be reserved wholly or partially for extractive development and/or resource protection. In many of the recently approved local and Regional/County Official Plans primary, and in some cases resources of secondary significance, are identified and protected.

Deposits of secondary significance are indicated by orange shading on Map 1. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resources in the report area, they may contain large quantities of sand and gravel and should be considered as part of the aggregate supply of the area.

Areas of tertiary significance are indicated by yellow shading. They are not considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs or extraction under a wayside permit but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of 2 sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

Site Specific Criteria

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall resources in the rest of the project area. Generally, deposits in Class 1 (greater than 6 m thick), and containing more than 35% gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in areas with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles comprising the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the deposit symbols. They are: gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the quality indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35% gravel in addition to a minimum of 20% material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10% may impede drainage in road subbase aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20% oversize material (greater than 10 cm in diameter) may also have use limitations. The oversize component is unacceptable for uncrushed road base, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

Another indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol shows either "C", "O", or "L", or any combination of these indicators, the quality of the deposit is considered to be reduced for some aggregate uses. No attempt is made to quantify the degree of limitation imposed. Assessment of the 4 indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation (MTO) and the Sedimentary Geoscience Section of the Ontario Geological Survey and from field observations.

Quality data may also appear in Table 9, where the results of MTO quality tests are listed by test type and sample location. The types of tests conducted and the test specifications are explained in Appendixes B and E, respectively.

Analyses of unprocessed samples obtained from test holes, pits or sample sites are plotted on grain size distribution graphs. On the graphs are the Ontario Ministry of Transportation's gradation specification envelopes for aggregate products: Granular A and Granular B Type 1; Hot-Laid Asphaltic Sand Nos. 1, 2, 3, 4 and 8; and concrete sand. By plotting the gradation curves with respect to the

specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product. These graphs, called Aggregate Grading Curves, follow the tables in the report.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural, environmental and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, power lines and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

In addition to man-made and cultural features, certain natural features, such as provincially significant wetlands, may prove to be contraints. In this report such constraints have not been outlined and the reader is advised to consult with municipal planning staff and the local office of the MNR for information on these matters. Depending on the number and type of constraints, anywhere from 15 to 80% of the total resources in a municipality can become inaccessible when these or other specific local constraints are considered (Planning Initiatives Limited 1993).

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. Since the approval under the Planning Act of the Mineral Aggregate Resource Policy Statement (MARPS) in the mid 1980s and the Comprehensive Set of Policy Statements, including MARPS, in March 1995, many of the more recently approved local and regional Official Plans now contain detailed policies regarding the location and operation of aggregate extraction activity and should be consulted at an early date in regard to considering the establishment of an aggregate extraction operation. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent office of MNR, and regional and local planning officials.

Regional Considerations

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand, and that the present production "market share" of an area will remain roughly at the same level. In most cases, however, the market demand for aggregate products, especially in urban areas, is greater than the amount of production found within the local market area. Consequently, conflicts often arise between the increasing demand for aggregates in such areas and the frequent pressures to restrict aggregate operations, especially in the near urban areas.

The aggregate resources in the region surrounding a project area should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, an area that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Areas with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 2: BEDROCK RESOURCES

Map 2 is an interpretative map derived from bedrock geology, drift thickness and bedrock topography maps, water well data from the Ontario Ministry of the Environment (MOE), oil and gas well data from the Non-Renewable Resources Section (MNR), and from geotechnical test hole data from various sources. Map 2 is based on concepts similar to those outlined for Map 1.

The geological boundaries of the Paleozoic bedrock units are shown by dashed lines. Isolated Paleozoic outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 1 m of drift, areas of 1 to 8 m of drift, and areas of 8 to 15 m of drift. The extent of these areas of thin drift are shown by 3 shades of grey. The darkest shade indicates where bedrock outcrops or is within 1 m of the ground surface. These areas constitute potential resource areas because of their easy access. The medium shade indicates areas where drift cover is up to 8 m thick. Quarrying is possible in this depth of overburden and these zones also represent potential resource areas. The lightest shade indicates bedrock areas overlain by 8 to 15 m of overburden. These latter areas constitute resources that have extractive value only in specific circumstances, such as when the bedrock has other industrial mineral uses (e.g., chemical lime and metallurgical rock). Outside of these delineated areas, the bedrock can be assumed to be covered by more than 15 m of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive deposits).

Other inventory information presented on Map 2 is designed to give an indication of the present level of extractive activity in the report area. Those areas which are licenced for extraction under the *Aggregate Resources Act* are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner/operator, licenced hectarage and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 2 and described in Table 5. Two additional symbols may appear on the map. An open dot indicates the location of a selected water well which penetrates bedrock. The overburden thickness in metres, is shown beside the open dot. Similarly, test hole locations appear as a point symbol with the depth to bedrock, in metres, shown beside it. The test holes may be further described in Table 7.

Selection Criteria

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation. The main characteristics and uses of the bedrock units found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource are usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

Selected Resource Areas

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approach. First, quality and quantity variations within a specific geological formation are gradual. Second the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas, if present, are shown on Map 2 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 2 are not permanent, single land use units. They represent areas in which a major bedrock resource is known to exist and may be reserved wholly or partially for extractive development and/or resource protection, within an Official Plan.

Part III – Assessment of Aggregate Resources in Victoria County

LOCATION AND POPULATION

Victoria County occupies 306 690 ha in south central Ontario. It is bounded by Simcoe County to the west, Haliburton County in the north, Peterborough County to the east and the Regional Municipality of Durham to the south and west. The county includes the townships of: Bexley; Carden; Dalton; Eldon; Emily; Fenelon; Laxton; Digby and Longford; Manvers; Mariposa; Ops; Somerville and Verulam (Figure 1). The study area is covered by parts of the Scugog (31D/2), Beaverton (31D/6), Lindsay (31D/7), Peterborough (31D/8), Fenelon Falls (31D/10), Orillia (31D/11), Gravenhurst (31D/14) and Minden (31D/15) 1:50 000 scale map sheets of the National Topographic System (NTS).

The population of Victoria County was 64 493 in 1994 (Ontario Ministry of Municipal Affairs 1995), which represents an increase of 17.0% since 1988 (Ontario Ministry of Municipal Affairs 1990). The largest community is the town of Lindsay that accounts for approximately 26% of the total population and is located in the central part of the county (Chart A). The village of Bobcaygeon is located on Sturgeon Lake near the eastern boundary of Victoria County and has a population of 2472. The third largest community is Fenelon Falls, located to the northwest of Bobcaygeon on the northern most tip of Sturgeon Lake.

Victoria County is serviced by a number of provincial highways including 7, 7A, 35, 36, 46, 48 and 121. These provincial highways are supplemented by secondary highways 503, 505 and well-maintained county and township roads. The southern and central parts of Victoria County have a fairly extensive road network. The northernmost townships of Laxton, Digby, Dalton and Longford are not as accessible. Victoria County is part of the Kawartha Lakes region and is a well known cottage and tourist area. The Trent Severn waterway passes through Victoria County.

SURFICIAL GEOLOGY AND PHYSIOGRAPHY

Victoria County encompasses portions of 6 physiographic regions as defined by Chapman and Putnam (1984). From south to north these include the: Oak Ridges Moraine, Schomberg Clay Plains, Peterborough Drumlin

Chart A – Area and Population
Victoria County

Municipality	Area (ha)	Population 1988	Population 1994
Bexley Township	12 266	1 019	1 209
Carden Township	18 684	609	803
Dalton Township	16 654	341	426
Eldon Township	25 685	2 292	2 804
Emily Township	24 092	5 350	6 254
Fenelon Township	22 251	5 141	5 567
Laxton, Digby and Longford Townships	46 850	841	994
Manvers Township	29 575	4 565	5 157
Mariposa Township	31 101	5 771	6 839
Ops Township	23 815	3 589	4 107
Somerville Township	28 345	1 756	2 092
Verulam Township	24 392	3 327	5 075
Lindsay	1 528	15 265	17 000
Bobcaygeon	487	1 944	2 472
Fenelon Falls	243	1 755	1 806
Omemee	326	872	1 097
Sturgeon Point	150	79	103
Woodville	246	616	688
TOTAL	**306 690**	**55 132**	**64 493**

Field, Dummer Moraine, Carden Plain and the Georgian Bay Fringe.

These physiographic regions and the distribution of unconsolidated sediments, including sand and gravel deposits, are the result of glacial activity that took place in the Late Wisconsinan Substage of the Pleistocene Epoch. This period of glacial activity began approximately 23 000 years before present (Barnett 1992a).

The Laurentide Ice sheet margin was split into a series of glacial lobes that behaved semi-independently. The map area was directly affected by the northern lobe and indirectly affected by the Lake Ontario lobe. Glacial ice from the northern lobe moved across Victoria County in a south to southwesterly direction (Gravenor 1957). The ice deposited large amounts of till throughout the southern and central parts of Victoria County. The areas of thicker till contain large streamline, linear landforms known as drumlins (Gravenor 1957).

Drumlins in the map area reach lengths of 2 km and have a relief of 15 to 30 m. They are composed of massive till, however, isolated pockets of stratified sand and gravel have been observed within these features and minor quantities of sand and gravel have been removed. The drumlins in Victoria County belong to the Peterborough Drumlin Field (Chapman and Putnam 1984) which extends from Hastings County in the east to Simcoe County in the west. The Newmarket Till forms the dominant surface sediment north of the Oak Ridges Moraine and is commonly associated with these drumlins. The Newmarket Till has been described as a silty sand to sandy silt till.

The Newmarket Till is usually missing along the broad, wide valleys that are common in the southern half of the county. These valleys have been interpreted as tunnel valleys and have eskers and other glaciofluvial sand and gravel deposits associated with them (Barnett 1994).

Ice from the Lake Ontario lobe moved in a westerly to northwesterly direction, essentially following the Lake Ontario basin. The northern and Lake Ontario lobes converged a few kilometres north of the present Lake Ontario shoreline. The Oak Ridges Moraine, reaching an elevation of approximately 230 m, is a dominant landform in the southern part of Victoria County. As the ice margin retreated, an opening was created between the 2 lobes that acted as a focus for meltwater flow and sediment deposition, thus forming the Oak Ridges Moraine.

Sediments that form the Oak Ridges Moraine are the product of a complex depositional history, possibly related to readvance and retreat of one or both ice margins bounding the moraine. For example, certain areas of the moraine are "till capped", leading Gravenor (1957) to suggest that northern ice retreated and then overrode the moraine depositing till over the interlobate sediments. Barnett (1997) does not include these "till capped" areas as part of the moraine. Gwyn (1976a) produced a cross-section of the Oak Ridges Moraine just south of the study area. The cross-section illustrates 4 different till units within the moraine structure.

The presence of fine sand and silt within and along the flanks of the moraine, prompted Gravenor (1957) to suggest that at one time a high level glacial lake may have been ponded between the northern and Lake Ontario lobes. Chapman (1985) supported this suggestion based on evidence in the Regional Municipality of Durham. It is clear from more recent information (Barnett 1992b, 1993, 1994) that the Oak Ridges Moraine is a composite of several depositional environments ranging from ice-contact to glaciolacustrine.

As the glacial ice retreated to the north, a series of post-glacial lakes were ponded in front of the receding ice margin. One of the largest of these was glacial Lake Algonquin. Centred in the Lake Huron basin, it covered what is now known as the Lake Simcoe area. Glacial Lake Algonquin created distinctive beach ridges located in Eldon and Carden townships. The small beach deposits tend to be thin and the stratified sand and gravel has been extracted through numerous small aggregate operations. Glaciolacustrine sand plains were also deposited but the sand is too fine for most aggregate uses.

Another area where water was ponded was around Lake Scugog. Chapman and Putnam (1984) include this area within the Schomberg Clay Plain physiographic unit. In this area, stratified clay and silt overlie till material and give the area a flat lying appearance. A few protruding drumlins offer some relief.

Gravenor (1957) believes that much of the deglaciation of Victoria County was accomplished by ice stagnation and melting-in-place. There are numerous ice-contact and outwash deposits throughout Victoria County. These are represented by eskers, outwash plains, subaqueous fans, kames and ice-contact stratified drift deposits. The eskers and kames were deposited by meltwater streams within or beneath the melting ice. They consist primarily of high-quality stratified sand and gravel deposits, which have for the most part, been used by the aggregate industry in the past.

The largest outwash deposits are found in northern Victoria County along Burnt River and north of Four Mile Lake in Somerville Township. These deposits contain fine sand with varying amounts of silt and clay and isolated pockets of coarser material. North of Talbot Lake, in Laxton Township, and northeast of Young Lake, in Dalton Township, are 2 ice-contact/subaqueous fan systems. These systems include features that were deposited in meltwater conduits within the ice or at the ice front where meltwater exited the conduits into a lake environment (subaqueous fan). Fine to coarse sand underlain by fine to coarse gravel characterize these deposits.

To the north of Sturgeon Lake, in Verulam Township, is another physiographic region known as the Dummer Moraine. The northern boundary of this physiographic unit usually coincides closely with the Paleozoic-Precambrian contact, but occasionally, the moraine extends a short distance north of the contact. The southern boundary is often vague because the moraine appears to be gradational with the Peterborough Drumlin Field to the south. Till within the Dummer Moraine is composed of large angular

boulders and pebbles in a coarse sand matrix. Paleozoic clasts are predominant and Precambrian clast content can be as low as 2% (Finamore 1982).

The origin of the Dummer Moraine is not well understood. Gravenor (1957) suggested that the Dummer Moraine represents a recessional moraine formed during the latter stages of glaciation in the study area. Brennand and Shaw (1994) offer other alternatives to the age and formation of the Dummer Moraine.

West of the Dummer Moraine and north of the Peterborough Drumlin Field is another physiographic unit called the Carden Plain (Chapman and Putnam 1984). Named for the township of Carden, the limestone plain forms a narrow east-trending band that increases in width from approximately 13 km just east of Orillia to 32 km farther east. The landscape is generally flat with small, north-facing escarpments rising 1 to 8 m. In general, Paleozoic bedrock in this region is covered by a thin veneer of till and glaciolacustrine sediments.

The northernmost areas of Victoria County lie within the Georgian Bay Fringe physiographic region (Chapman and Putnam 1984). This area is characterized by very shallow soil and bare rock knobs and ridges. The bedrock is Precambrian in age and potential aggregate deposits are limited. This area is characterized by numerous outcrops of Precambrian granite, granitic gneiss and migmatite. These outcrops impart a rugged appearance to the landscape, although collectively the outcrop belt represents a low relief plain with a maximum relief of approximately 6 to 9 m (Deane 1950, Deane and Pollitt 1950).

Low-lying areas between outcrops in the Georgian Bay Fringe region are covered by a thin layer of till or ground moraine composed of a loose, sandy, reddish till derived primarily from Precambrian bedrock. The rock-knob lowland was subsequently inundated by glacial Lake Algonquin resulting in the deposition of thin glaciolacustrine sediments over till. During lower stages of this lake, Precambrian outcrops were swept clear of sediments by wave action.

Postglacial erosional and depositional processes have been of relatively minor importance in modifying the physiography of Victoria County. Recent alluvial and lacustrine deposits consisting of clay, silt, sand and minor fine gravel are found throughout Victoria County along river banks and the shorelines of lakes. The high concentration of fine materials generally make these deposits unsuitable for aggregate use.

Since the departure of the glacial ice, low-lying and/or poorly drained areas have developed accumulations of organic materials. Marshes and swamps have formed in many of these localized depressions throughout the county. Some of the more notable wetland areas are those in the vicinity of Lake Scugog in Manvers and Ops townships and in the valleys of Staples River and Grass Creek in Eldon Township.

EXTRACTIVE ACTIVITY

Sand and gravel extractive activity in Victoria County is mainly concentrated in Manvers, Emily, Mariposa and Fenelon townships. Licenced pits are primarily located in large ice-contact/esker complexes, subaqueous fans, other ice-contact and outwash deposits. Some small pits are located within a few glaciolacustrine beach deposits. Quarries are concentrated in the northern half of the county where Paleozoic limestones, dolostones and dolomitic limestones are being extracted for crushing and decorative stone.

Currently, 131 pits and quarries, occupying 4567.94 ha, are licenced under the *Aggregate Resources Act*. Chart B shows the average annual aggregate production figures, the number of licenced pits and quarries, the total licenced area for each township and totals for the county. Manvers Township has a long history of aggregate production. It consistently is one of the top 10 aggregate producing municipalities in the province. In 1996, Manvers was 5TH with a production of 3.6 million tonnes (Ontario Ministry of Natural Resources 1996).

SELECTED SAND AND GRAVEL RESOURCE AREAS

Maps 1A and 1B depict all the surficial deposits that contain sand and gravel in the report area. These maps are based on previously published ARIP maps (Ontario Geological Survey 1980a-f, 1981a, 1981b, 1981c, 1992a, 1992b), recent Quaternary maps of the area (Finamore and Bajc 1983, 1984; Barnett 1997) and field observations. The deposits of sand and gravel occupy 55 221 ha and contain an original resource tonnage of 3124.9 million tonnes (Table 1). **These figures represent a comprehensive inventory of all granular materials in the study area, although much of the material included in the estimate has no potential and some is unavailable for extraction due to land use restrictions.**

The best quality and most extensive sand and gravel deposits are in the southern part of the county, particularly in the Oak Ridges Moraine. In the northern part of the county, many of the sand and gravel deposits have limited potential for extraction because of restricted quantities, poor quality and limited accessibility. Fortunately, the northern part of Victoria County has large expanses of thinly drift covered bedrock, which can be used to produce crushed bedrock derived aggregates.

Twenty-four areas have been designated as Selected Sand and Gravel Resource Areas of primary significance in Victoria County and many additional areas have been designated at the secondary level of significance. The main aggregate containing deposits in the county are eskers, subaqueous fans and other ice-contract deposits. Additional resources are available from outwash and glaciolacustrine beach deposits. The material from these deposits is capable of supplying high- and low-specification aggregate. Variability of material within the deposits is common and selective extraction and blending may be necessary.

Chart B - Summary of Extractive Activity
Victoria County

Municipality	Average Annual Aggregate Production 1990 to 1994 (tonnes)	Number of Licences		Total Licenced Area (ha)	
		Pits	Quarries	Pits	Quarries
Bexley Township	26 931.57	2	0	152.80	
Carden Township	824 225.75	1	4	14.17	668.07
Dalton Township	3 531.70	2	0	14.00	
Eldon Township	148 272.16	12	0	162.10	
Emily Township	360 379.97	19	0	421.00	
Fenelon Township	305 883.67	16	0	553.40	
Laxton, Digby and Longford Townships	31 011.04	7	3	105.70	93.25*
Manvers Township	3 193 207.40	17	0	1368.20	
Mariposa Township	363 788.69	20	0	403.79	
Ops	906.89	2	0	36.39	
Somerville Township	154 140.59	9	4	198.32	159.98*
Verulam Township	100 043.24	13	0	216.77	
TOTAL	**5 512 322.77**	**120**	**11**	**3646.64**	**921.30**

* For sites licenced as both pits and quarries, the licenced areas have only been included in the total licenced areas for pits.

The Selected Sand and Gravel Resource Areas cover 7477 ha of which 5811 ha are potentially available for extraction. The possible sand and gravel resources from these areas are estimated to be 747.5 million tonnes (Table 3).

Selected Sand and Gravel Resource Area 1

Ice-contact/subaqueous fan deposits in western Dalton Township have been designated as Selected Sand and Gravel Resource Area 1. The resource area consists of a series of gently sloping northeast-trending ridges with the exception of area 1d which forms a prominent ridge which rises more than 6 m above the surrounding terrain.

Three different sediment types are common within the deposits. One type is a silty fine to medium sand that may contain frequent silt seams. This material is the predominant material exposed in Pit Nos. 21 and 23. The second sediment type is a gravelly sand with between 15 and 45% fine gravel. The aggregate typically underlies varying thicknesses of the silty fine to medium sand. The gravelly sand has been extracted from Pit Nos. 10 and 16 and from below the water table in the floor of Pit No. 23. The third type is fine to coarse material containing between 50 and 70% gravel. This coarse aggregate often occurs at depth within the deposit and occasionally near the surface. Pit Nos. 15 and 22 contained pockets of this material. Pit faces range in height from 1.5 to 6.1 m within the resource area (Table 2).

Selected Sand and Gravel Resource Area 1 is a major aggregate resource in Dalton Township. The aggregate quality varies depending on the type of material present. The silty sand is generally suitable only for low-specification sand uses including SSM and blending sand. Sections that contain excessive quantities of silt should be avoided. The gravelly sand appears well suited for granular subbase. Crushed gravel may be produced with selective extraction of coarse gravel pockets. Samples taken from Pit Nos. 15 and 22 contained hard and durable aggregate which met MTO quality criteria for products including hot-laid asphaltic stone products and Granular A (Ontario Geological Survey 1992b).

Overall, the resource area is primarily a potential source of sandy aggregate suitable for granular subbase and low-specification sand products. The parts of the deposits with the highest elevations have the highest potential for containing coarse aggregate at depth. The prominent ridge that forms area 1d is one such high potential area.

Approximately 194 ha are potentially available for extraction in Selected Sand and Gravel Resource Area 1. The average thickness of each deposit varies from 4.5 to 6 m, therefore, possible sand and gravel resources are estimated

at 15.7 million tonnes (Table 3). Some of the segments of the deposit are accessible by township roads while others have limited access.

Selected Sand and Gravel Resource Area 2

Selected Sand and Gravel Resource Area 2 consists of 2 subaqueous fan deposits located in northeastern Dalton Township. The pits identified in Selected Sand and Gravel Resource Area 2 have been developed in areas where higher concentrations of gravel are exposed at the surface. Fine to medium sand is the predominant material exposed at the surface away from the pit areas. Pit Nos. 13 and 14 expose gravelly sand with an estimated 30 to 40% gravel content. The gravel in Pit No. 12 is concentrated in pockets within predominantly sandy material. The gravel content varies from 10 to 50%. Faces in the pit areas range from 1.5 to 3.0 m. Bedrock is exposed in the floor of Pit No. 12.

Pit Nos. 13 and 14 contain aggregate that is well suited for the production of Granular B. Selective extraction of coarse material from Pit No. 12 may be necessary for the production of granular subbase. Further subsurface investigation is required to determine if similar aggregate to that exposed in the pit areas underlies the undeveloped parts of the resource area.

Selected Sand and Gravel Resource Area 2 is approximately 38 ha, of which 29 ha are potentially available for extraction. Assuming an average deposit thickness of 4 m, the possible aggregate resource would be 2.0 million tonnes (Table 3). A gravel road provides access to this area.

Selected Sand and Gravel Resource Area 3

Selected Sand and Gravel Resource Area 3 is located in eastern Laxton Township and is designated as areas 3a to 3c on Map 1A. This resource area consists of a series of gently sloping, northeast-trending ridges of ice-contact/subaqueous fan origin.

Pit faces in these deposits expose material typical of ice-contact/subaqueous fans. The aggregate tends to become finer towards the surface and flanks of the deposits. The area consists of similar materials to that previously described for Selected Sand and Gravel Resource Area 1. Silty fine to medium sand was common in the upper levels of the pit faces and along the flanks of the deposits.

The upper 3 m of Pit No. 35, the upper 1.5 m of Pit No. 43 and most of the faces in Pit Nos. 32 and 36 consist of fine aggregate. Faces in Pit No. 40 and the lower levels of the north part of Pit Nos. 35 and 43 consist of gravelly sand. Pockets of coarse gravel have been extracted from below the water table in the floors of Pit Nos. 32 and 36, the southern part of Pit No. 35 and the floor of Pit No. 40. The thickness of fine material above the coarser aggregate ranges from 2.4 to 7.6 m in these pit areas. Faces in Pit No. 33 consist entirely of fine to coarse gravel. Pockets of fine to coarse gravel also exist in Pit No. 47. The gravel in Selected Sand and Gravel Resource Area 3 is primarily Precambrian bedrock clasts with the exception of the southern tip of area 3c that also contains Paleozoic clasts.

The deposits are considered to be a valuable source of aggregate in an area lacking sand and gravel deposits. Aggregate products produced from the resource area are dependent on the type of material present. The silty sand is generally suitable for low-specification sand uses such as SSM. Sections that contain excessive silt seams should be avoided. Pit-run granular subbase can potentially be produced from the gravelly sand.

A sample taken from Pit No. 40 appears well suited to the production of Granular B (Ontario Geological Survey 1992b). The fine to coarse gravel is potentially suitable for the production of crushed gravel for use in Granular A and hot-laid asphaltic stone. Where this coarse material occurs as pockets within finer aggregate, selective extraction and sand control may be necessary for crushing. Sections consisting predominantly of this coarse aggregate, as in Pit No. 33, exhibit the greatest potential for crushing. A sample of the aggregate from Pit No. 33 appears well suited for the production of Granular A and M (Ontario Geological Survey 1992b).

In general, the resource area is considered primarily as a source of pit-run aggregate suitable for SSM and Granular B subbase, however, limited amounts of crushable gravel are available. Additional resources of fine to coarse gravel may be discovered by concentrating subsurface exploration below the crest of the ridge along the central part of the deposit. The gravel tends to be closer to the surface in areas where the underlying bedrock is relatively close to the surface.

Selected Sand and Gravel Resource Area 3 occupies 277 ha of which approximately 168 ha are potentially available for extraction. Assuming average deposit thicknesses ranging from 4 to 5.5 m, possible sand and gravel resources total 14.0 million tonnes (Table 3). Access to the area is provided by Highway 35, secondary Highway 503 and township roads.

Selected Sand and Gravel Resource Area 4

Selected Sand and Gravel Resource Area 4 consists of 2 esker segments, one mainly located in Carden Township (Area 4a) and the other extending from Bexley Township into Carden and Eldon townships (Area 4b). Pit No. 57 was developed along the southern boundary of area 4a. Face heights in the pit were up to 5 m and exposed poorly sorted, stratified gravel well suited for the production of crushed roadbase aggregate.

Subsurface information for the rest of the resource area is limited. MTO excavated several test holes in resource area 4b to the east of Highway 505 in Bexley Township. They exposed 1.5 to more than 5 m of aggregate, primarily gravel. Material in these deposits is expected to be variable and further subsurface investigation is recommended.

The total area of Selected Sand and Gravel Resource Area 4 is 128 ha, of which 124 ha are potentially available for extraction. Assuming an average thickness of 4 m for area 4a and 2.5 m for area 4b, possible sand and gravel resources are estimated to be 6.8 million tonnes (Table 3). Township and county roads provide access to the area.

Selected Sand and Gravel Resource Area 5

Selected Sand and Gravel Resource Area 5 is an esker located north of Raven Lake in Bexley Township. Two pits have been developed along the western flank of the esker. One is a licenced operation, Pit No. 58, which has face heights of 2 to 3 m. The second pit is an unlicenced property, Pit No. 60, which also has 2 to 3 m faces. Pit No. 58 is primarily used as a sand source while Pit No. 60 has a higher percentage of gravel. Material in Pit No. 60 is better suited for road building and construction aggregate, although further processing may be required because of the presence of shale and oversize material.

This deposit has an estimated 96 ha potentially available for extraction. Assuming an average deposit thickness of 5 m, the deposit contains possible resources of 8.5 million tonnes (Table 3). Access is provided by township roads.

Selected Sand and Gravel Resource Area 6

Selected Sand and Gravel Resource Area 6 consists of an esker ridge and 2 associated ice-contact deposits in the southeastern corner of Bexley Township. Licenced Pit No. 59 has been developed in resource area 6. The faces of this pit range from 2 to 10 m and expose poorly to moderately sorted sand and gravel. The coarser material in the core of the esker is flanked by siltier, sandier material.

The material in the pit is well suited for a variety of road building and construction aggregate. The presence of oversize material imposes quality constraints. The 2 ice-contact deposits are expected to contain smaller amounts of material similar to that found in the central esker ridge.

The resource area occupies a total of 77 ha. Cultural constraints and previously extracted areas reduce the area potentially available for extraction to 65 ha. Assuming an average deposit thickness of 6 m possible sand and gravel resources in resource area 6 are estimated to be 6.9 million tonnes. Access to this resource area is provided by Highway 48.

Selected Sand and Gravel Resource Area 7

Selected Sand and Gravel Resource Area 7 consists of an outwash/glaciolacustrine deposit located in central Somerville Township. Three pits have been developed in this feature. Pit Nos. 90 and 91 have faces between 1 and 2 m, exposing predominantly fine to medium sand. In the northern part of Pit No. 67, the faces range from 6 to 11 m and expose 0.6 m of very fine sand, with silt and clay, overlying primarily fine sand. The north face contained fine to medium gravel lenses approximately 1 m thick. Crushable material may be available with selective extraction of these lenses. The material exposed in the 3 to 6 m faces of the southern part of Pit No. 67 was also variable. Fine to coarse sand was the predominant material present but there were also fine gravel lenses approximately 0.6 m thick.

A sample taken from Pit No. 91 contained 2% gravel, 97% sand and 1% fines (Ontario Geological Survey 1992a). This sample appears suitable for some asphalt sand products and is borderline for use as Granular B. Several test holes were excavated by the MTO in the vicinity of Pit No. 67. Sand was the predominant material uncovered, however, there were pockets of coarser material. Further subsurface investigation is necessary to determine the quality of the material available for extraction.

Selected Sand and Gravel Resource Area 7 occupies approximately 37 ha of which 31 ha are potentially available for extraction. Based on an average thickness estimate of 5 m, possible aggregate resources total 2.7 million tonnes. This area is easily accessed by road.

Selected Sand and Gravel Resource Area 8

Selected Sand and Gravel Resource Area 8 is a large ice-contact stratified drift deposit located in northeastern Eldon Township. The topography of the deposit is hummocky with relief generally less than 15 m.

Five pits (Pit Nos. 122, 123, 133, 134 and 135) have been developed in this resource area. Pit faces range from 1 to 20 m and expose primarily poor to well-sorted, irregularly bedded sand and gravel. Isolated pockets of crushable gravel do occur, however, pockets of very fine sand and silt are also present. Test holes excavated by the MTO in Pit No. 122 expose pockets of crushable material. Across the deposit, the quality of the aggregate will vary greatly and selective extraction and sand control may be required for some products. The deposit is generally capable of supplying low-specification aggregate with minor amounts of high-specification aggregate.

The resource area occupies approximately 300 ha exclusive of licenced properties. Previous extraction and cultural constraints reduce the area potentially available to 254 ha. Assuming an average deposit thickness of 5 m, possible sand and gravel resources are estimated to be 22.5 million tonnes (Table 3). Highway 48 cuts through this deposit from east to west.

Selected Sand and Gravel Resource Area 9

Selected Sand and Gravel Resource Area 9 is an ice-contact deposit located in northern Eldon Township. The deposit forms an irregular isolated knoll with local relief of more than 30 m. Pit Nos. 118, 119, 120 and 132 have been developed in the deposit and their faces range in height from 3 to 8 m. Poor to well-sorted sand and minor gravel have been exposed in the pit areas. The gravel beds are ex-

tremely variable and may occur as isolated lenses and pockets within the sand.

The material has been used for a wide range of road building and construction products, however, the irregular occurrence of the gravel limits the production of crushed aggregate. The sand in the pit areas is suitable for a range of hot-laid asphaltic aggregate products but blending may be required when the sand is too fine or dirty.

Selected Sand and Gravel Resource Area 9 occupies 116 ha exclusive of licenced areas. Cultural setbacks and previous extraction reduce the area currently available to 104 ha. Assuming an average deposit thickness of 6 m, possible available resources are estimated to be 11.0 million tonnes (Table 3). The area is accessible by Highway 46.

Selected Sand and Gravel Resource Area 10

An ice-contact deposit in southeastern Eldon Township represents Selected Sand and Gravel Resource Area 10. Three licenced pits have been developed in the deposit (Pit Nos. 126, 127 and 128). The pit faces range from 2 to 20 m and expose poor to well-sorted, stratified sand and gravel. The material is of good quality, although excess fines and particle cementation in some areas may restrict the use of the aggregate. The material is suitable for a wide range of aggregate products.

The total area for Selected Sand and Gravel Resource Area 10 is 202 ha, exclusive of licenced properties. The area potentially available for extraction is approximately 175 ha. The deposit thickness is about 11 m and possible aggregate resources are estimated to be 34.1 million tonnes (Table 3). Access to the area is by county and township roads.

Selected Sand and Gravel Resource Area 11

Two ice-contact deposits in the north-central part of Fenelon Township have been designated as Selected Sand and Gravel Resource Area 11. Four licenced pits (Pit Nos. 147, 148, 149, and 159) have been developed in the resource area. Faces in the pit areas expose 2 to 9 m of poorly sorted sand and coarse gravel. The aggregate from Pit Nos. 148 and 149, in area 11a, has been used for a variety of road building and construction products. Oversize material must be removed or crushed. In some places, the sand fraction may be either too coarse or too fine for some grades of hot-laid asphaltic sand and would require blending. A sample taken from the northern part of Pit No. 147 appears to be suitable for Granular A and B with the removal or crushing of the oversize material (Figures 4a and 4b).

Selected Sand and Gravel Resource area 11 occupies approximately 389 ha, exclusive of licenced areas. Cultural constraints reduce the potentially available area to 335 ha. Assuming an average thickness of 6 m for area 11a and 5 m for area 11b, 31.0 million tonnes of sand and gravel may be available for extraction (Table 3). Access to the area is by Highway 35 and gravel township roads.

Selected Sand and Gravel Resource Area 12

Selected Sand and Gravel Resource Area 12 is an esker deposit that trends to the southwest through the centre of Fenelon Township. The deposit consists of three segments, 2 of which are single ridges approximately 15 m high and 2.4 km long. The third segment is considerably smaller. Each segment is flanked by ice-contact material.

Several licenced pits, Pit Nos. 155, 156, 157 and 158, have been developed in resource area 12. Faces in the pit areas range from 3 to 18 m, and expose poorly to moderately sorted, medium to coarse sand and gravel. The aggregate from these pits has been used for high-specification granular and hot-laid asphalt products. In places, oversize material would have to be removed or crushed. In dirty sections, blending would be required to produce hot-laid asphaltic sand. Several of the pits are capable of providing a wide range of aggregate products of uniformly high quality.

The esker segments that constitute Selected Sand and Gravel Resource Area 12 have a total area of 78 ha exclusive of the licenced areas. Cultural setbacks and previous extraction reduce the area potentially available for extraction to 64 ha. Assuming an average thickness of 6 m, possible sand and gravel resources are estimated to be 6.8 million tonnes (Table 3). Township roads and Highway 35 provide access to the area.

Selected Sand and Gravel Resource Area 13

Selected Sand and Gravel Resource Area 13 is a large ice-contact deposit that flanks the esker segments described in resource area 12. The resource area has irregular, hummocky topography characteristic of ice-contact deposits. Local relief is as much as 46 m near Zion in the south end of the selected area.

Numerous pits have been developed in the resource area. Faces in the pit areas range from 6 to 30 m and expose poor to well-sorted, irregularly stratified sand and gravel. Gravel is found primarily in isolated pockets and lenses within the sandy sediment. The aggregate from Pit No. 150 is suitable for a wide range of aggregate products but oversize material must be removed or crushed in sections for Granular B. Sand control is necessary for Granular A and blending is required for hot-laid asphaltic sand. The aggregate available from the resource areas is variable in quality but with some processing it can be used for a wide range of products.

MTO excavated numerous test holes in the western portion of Selected Sand and Gravel Resource Area 13. These test holes reveal the variability in the depth and quality of the material. One test hole revealed sand in one face and gravel in the opposite face. Gravel would have to be selectively extracted. The silt content in sand and gravel

could be excessive. Test holes immediately to the west of Pit No. 155, revealed sand with areas of crushable gravel.

Selected Sand and Gravel Resource Area 13 occupies 769 ha, exclusive of licenced areas. Cultural constraints reduce the area available for extraction to 692 ha. Assuming an average deposit thickness of 7 m, possible sand and gravel resources are estimated to be 85.7 million tonnes. The deposit is accessible by a network of township roads and Highway 35.

Selected Sand and Gravel Resource Area 14

An esker and ice-contact stratified drift complex located along the township boundary in northern Fenelon and Verulam townships has been designated at the primary level of significance. The area consists of a central esker ridge flanked by ice-contact deposits. Four pits, Pit Nos. 164, 171, 185 and 186) have been developed in the resource area.

The pit faces expose from 2 to 15 m of poorly to moderately sorted sand and medium to coarse gravel. The sediments have been used to produce crushed material and is acceptable for a wide range of products. Oversize material may have to be removed or crushed. The sand fraction of the aggregate often grades too coarse or dirty and, in some cases, is not suitable for any granular use. Subsurface investigation is recommended before any extractive development is undertaken.

The esker/ice-contact complex occupies a total of 273 ha. Approximately 235 ha are potentially available for extraction. Assuming an average deposit thickness of 5 m throughout all parts of the resource area, possible resources of sand and gravel are estimated at 20.8 million tonnes (Table 3). This area is readily accessible by numerous township roads.

Selected Sand and Gravel Resource Area 15

Selected Sand and Gravel Resource Area 15 is an ice-contact deposit located along the west shore of Pigeon Lake in Verulam and Emily townships. Several pits have been opened in the deposit but most have been abandoned for a long time. Only one pit is presently licenced for extraction (Pit No. 182). Faces in the pit vary from 3 to 6 m and expose moderately sorted sand and gravel. The deposit contains significant amounts of gravel and crushable material has been removed.

Resource area 15 occupies 215 ha, exclusive of the licenced area. Previous extraction and cultural constraints reduce the potentially available extractive area to 76 ha. Assuming an average thickness of 5 m, possible sand and gravel resources are estimated to be 6.7 million tonnes (Table 3). Access to the deposit is by township roads and Highway 36 located to the north.

Selected Sand and Gravel Resource Area 16

A large esker complex in northern Mariposa Township is designated as a resource area of primary significance. Only the central ridge, where the esker deposit is highly developed, has been selected. The deposit is a locally important source of crushable aggregate and will probably continue to be for the future.

A considerable number of sand and gravel pits have been developed in the esker. A large portion of the deposit is currently under licence for extraction. Faces in the pit areas range from 3 to 18 m and expose a wide range of granular materials. Well-sorted, stratified sand and gravel are evident in places but pockets of poorly sorted gravel as well as areas of silty sand also occur. Overall, with selective extraction, high-quality aggregate is available. Several of the large pits in the selected resource area 16b have water and clay in the floor of the excavated area. In resource area 16a, Pit No. 206 had water in the floor of the pit but crushable material had been removed from below water level.

Aggregate from Selected Sand and Gravel Resource Area 16 is generally suitable for a wide range of road building and construction products. In the central core of the esker, oversize material is prevalent and must be removed or crushed. In the sandier material flanking the core, selection and sand control is often required to produce crushable material. In some pits, testing of the material has indicated that the stone quality is too poor for the production of some grades of hot-laid asphaltic aggregate. The production of asphaltic sand sometimes requires blending due to the high fines content.

Resource area 16 covers 207 ha, exclusive of licenced areas. Cultural constraints reduce the area available to 155 ha. Assuming an average deposit thickness of 5 m, available sand and gravel resources total approximately 13.7 million tonnes. Access to the area is provided by township roads and it is located near Highway 46.

Selected Sand and Gravel Resource Area 17

Selected Sand and Gravel Resource Area 17 is an esker deposit located on the western boundary of Mariposa Township. One licenced pit, Pit No. 210, exposes 6 to 9 m of poorly sorted, massive sand and gravel. MTO information indicates that the aggregate is suitable for most crushed base coarse products as well as for some select subgrade materials (Deike 1977). The presence of silt, shale and oversize material may limit the suitability of the aggregate for some uses.

The total area of resource area 17 is 9 ha of which 8 ha are presently available for extraction. Estimated sand and gravel resources total 0.9 million tonnes based on an average deposit thickness of 6 m (Table 3). This deposit may seem too small to select as a primary resource but the deposit continues in a southwesterly direction into the Regional Municipality of Durham where it has been selected

at the primary level of significance (MacNaughton, Hermsen, Britton, Clarkson Planning Ltd. and the Ontario Geological Survey 1999). Access is provided by a county road.

Selected Sand and Gravel Resource Area 18

Selected Sand and Gravel Resource Area 18 is an esker deposit that trends southwest from the town of Lindsay. The deposit consists of a single ridge approximately 30 to 76 m in width and ranging in height from 5 to 11 m. Aggregate has been extracted from the esker for many years. The material has been used to meet local aggregate demand.

Pit Nos. 230, 231, 232 and 234 have been developed along the esker deposit. The pit faces range from 2 to 8 m and expose poorly to moderately sorted gravel with numerous sandy layers. The gravel content is quite variable throughout the deposit making sand selection and control a common requirement for the production of crushed aggregate products. In many places, the gravel is coated with silt and clay and may be interlayered with clay seams. As a result, the aggregate is often unsuitable for higher specification uses. The gradation and lithology of the aggregate are generally good. When the aggregate is relatively clean, it is suitable for a wide range of road building and construction products, including Granular A, B and hot-laid asphaltic products.

The selected resource area consists of 126 ha. Prior extraction combined with cultural development on the southern fringes of the town of Lindsay has made much of the remaining resources unavailable. The area potentially available for extraction is calculated to be 63 ha. Assuming an average deposit thickness of 6 m, possible sand and gravel resources are estimated to be 6.7 million tonnes (Table 3). Highway 7 and township roads provide access to this deposit.

Selected Sand and Gravel Resource Area 19

A large esker in western Emily Township has been designated as Selected Sand and Gravel Resource Area 19. A single esker ridge runs from Fees Landing to the southwest corner of the township and a second ridge trends northward to Downeyville and beyond.

Numerous pits have been developed in the deposit. Face heights range from 3 to 20 m and expose poorly to moderately sorted, stratified sand and fine to coarse gravel. Material from these pit areas is suitable for a wide range of aggregate products, although removal or crushing oversize material is often required for granular base. The fine fraction of the deposit is often too coarse and dirty for hot-laid asphalt. A sample taken from a roadcut near licenced Pit No. 247 was tested by MTO and found to be suitable for Granular B, however, the PN value is slightly high for some hot-laid products and concrete (Figures 5A and 5B). Samples previously tested by MTO at Pit Nos. 250 and 267 also indicate PN values slightly higher than acceptable for hot-laid asphaltic products.

Resource area 19 consists of 275 ha, exclusive of licenced areas. Previous extraction and cultural setback requirements reduce the potential area available to 202 ha. Assuming an average deposit thickness of 7 m, sand and gravel resources are estimated to be 25.0 million tonnes (Table 3). Access to the area is by township roads and Highway 7 in the south.

Selected Sand and Gravel Resource Area 20

Selected Sand and Gravel Resource Area 20 is a ice-contact deposit situated at the southwest end of Pigeon Lake in Emily Township. The 5 pits (Pit Nos. 253 to 256 and 278) in the deposit have face heights that range from 2 to 25 m. The material exposed in the pit areas was primarily poorly to well-sorted, interlayered sand and gravel. Large areas of fine sand and silty sand also occurred. Selective extraction is necessary in some areas to access crushable material. The sand generally requires blending to produce hot-laid asphaltic sand.

Approximately 283 ha are available for extraction in Selected Sand and Gravel Resource Area 20, exclusive of licenced areas, cultural setbacks and previously extracted areas. A large portion of this deposit along the shore of Pigeon Lake is not available for extraction due to the presence of residential and recreational development. The thickness of aggregate varies across the deposit but based on an average deposit thickness of 8 m, sand and gravel resources are estimated to be 40.1 million tonnes (Table 3). Township roads provide access to the deposit.

Selected Sand and Gravel Resource Area 21

In southern Emily Township, east of Omemee, a large ice-contact deposit is designated as Selected Sand and Gravel Resource Area 21. The deposit is undulating with large knolls and low depressions. Numerous pits have been developed in resource area 21. Face heights in Pit Nos. 258 to 262 and 283 to 288 range from 3 to 20 m and expose variably sorted and stratified sand and gravel characteristic of ice-contact stratified drift deposits.

The aggregate in resource area 21 is suitable for a wide range of road building and construction products. Crushable gravel occurs sporadically across the deposit so selective extraction and sand control are usually required. Some areas of the deposit are only capable of producing low-specification aggregate; excess silt and clay can be a problem. The variable character of this deposit necessitates subsurface investigation before development is undertaken.

The total area of the deposit is 1040 ha, exclusive of licenced areas. Previous extraction and cultural setbacks reduce the area currently available to 776 ha. Assuming an average deposit thickness of 6 m, sand and gravel resources are estimated to be 82.4 million tonnes (Table 3). The area is accessible by Highway 7 and gravel and paved roads. It is located close to the village of Omemee.

Selected Sand and Gravel Resource Area 22

In the northeast corner of Manvers Township and the southwest corner of Emily Township is an ice-contact/esker complex designated as Selected Sand and Gravel Resource Area 22. The main esker ridge is sinuous, segmented and has several smaller branches. Relief of the ridge ranges from 9 to 23 m and the width varies from 91 to 183 m. A few well-developed ice-contact deposits are associated with the esker.

Pit faces throughout the deposit expose moderately sorted pebble to cobble gravel and sand in the esker ridge, and stratified sand and minor gravel along the flanks of the deposit. Pit No. 290 is capable of producing Granular A, concrete stone and some hot-laid asphaltic sand with blending. In some parts of the deposit, oversize material must be removed or crushed for the production of crushed aggregate. In other areas, the crushable gravel content is low and selection and sand control are required for crushed products.

Selected Sand and Gravel Resource Area 22 has an area of 231 ha, exclusive of the licenced area. Cultural setbacks and previously extracted areas reduce the potential extractive areas to 192 ha. Assuming an average deposit thickness of 5 m, possible sand and gravel resources in resource area 22 are estimated to be 17.0 million tonnes (Table 3). A number of township roads provide access to the resource area.

Selected Sand and Gravel Resource Area 23

An esker/ice-contact deposit in eastern Manvers Township has been designated at the primary level of significance. Pit No. 317 in the deposit exposes moderately sorted sand and minor gravel in a 9 m high pit face. The lack of crushable material will limit the aggregate products available from this pit. Several of the pits in the southern part of the deposit have been rehabilitated, however, a sample was taken from rehabilitated Pit No. 321 and tested. The sample was found to be suitable for Granular B and possibly Granular A with crushing (Figures 5a and 5b).

Selected Sand and Gravel Resource Area 23 has an area of 88 ha, exclusive of the licenced area. The community of Bethany and previous extraction has reduced the area available for extraction to 68 ha. Assuming an average deposit thickness of 8 m, Selected Sand and Gravel Resource Area 23 has possible resources of 9.6 million tonnes (Table 3). Access is provided by Highway 7A.

Selected Sand and Gravel Resource Area 24

Selected Sand and Gravel Resource Area 24 includes both the central portion of the Oak Ridges Moraine along the southern boundary of Manvers Township, and a north-trending spur of the moraine which extends past Pontypool.

Resource area 24 is considered to have generally greater potential for further development than the surrounding morainic deposits (Gwyn 1976b). First, as shown by the concentration of existing pits, the area is a traditional aggregate source, in contrast to the rest of the moraine which is relatively undeveloped. Second, pit exposures as well as other subsurface data, indicate a greater proportion of coarse granular material in resource area 24 than in the surrounding deposits. Finally, the relief of the area is often greater, and the terrain more hummocky and irregular than other portions of the moraine.

In the southern portion of the resource area, there are currently 11 licenced pits. The pit faces expose generally well-sorted and stratified sand with minor amounts of gravel. MTO information for the resource area reflects the highly variable nature of this deposit. Pockets and seams of gravel suitable for crushing do occur but seams of silt and fine sand also occur. Numerous test holes excavated in the south-central portion of the selected resource area encountered silt between 2 and 9 m below the surface. Numerous inactive or abandoned pits are scattered throughout the deposit. The 3 to 9 m faces in these pits expose well-sorted and stratified, medium to coarse sand and minor medium gravel.

The pits in this area have produced a wide range of high- and low-specification aggregates. The quality of the aggregate will vary greatly even within a pit. MTO testing of samples from test holes does not indicate any general characteristics of the aggregate. Some samples were suitable for Granular A and B, others required sand control or the removal of oversize material or were unacceptable due to the fineness of the material. Blending may be necessary to produce hot-laid asphaltic stone and sand. A lot of the MTO samples graded too coarse for hot-laid (HL) 3 and some graded too fine for HL8. Compaction may also be a problem due to a lack of fines and uniformity of grain size. Selective extraction is necessary to ensure the quality of any aggregate product.

Recent testing in the Regional Municipality of Durham indicates that gravel content may vary from less than 10% to more than 50% over quite short distances both laterally and vertically (MacNaughton, Hermsen, Britton, Clarkson Planning Ltd. and the Ontario Geological Survey 1999). Extensive site investigation may be required prior to resource development and extraction.

The resource area covers a total area of 1820 ha, exclusive of licenced areas. Residential and other development along Highway 35 and surrounding Pontypool have removed some of the area from consideration for extraction. Cultural setbacks and previously extracted areas leave an area of 1422 ha currently available for extraction. Assuming an average deposit thickness of 11 m, sand and gravel resources are estimated to be 276.9 million tonnes (Table 3). Road access to the area is provided by Highway 35 that runs north to south through the deposit. Highway 35 connects with highways to the south and ultimately to markets in the Greater Toronto Area.

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

Map 1A

Four outwash and outwash/glaciolacustrine plain deposits in the northern half of Longford Township have been selected as resource areas of secondary significance. Pit Nos. 3 and 4 in the north-central part of the township have aggregate suitable for granular subbase. A sample taken from Pit No. 4 met quality criteria for Granular B (Ontario Geological Survey 1992b) having a gravel content of greater than 50%. The face of Pit No. 6, further south, has 1.5 m of medium sand to sandy fine gravel. The material in this deposit appears suitable for use on local cottage and forest-access roads. The undeveloped deposit in the northwestern corner of the township is considered to be a potential source of pit-run sand. Additional subsurface information would be required to determine the nature of the materials at depth.

Three ice-contact deposits in southern Longford and northern Digby townships have been selected as areas of secondary significance. Two pits have been opened in these deposits. The 1.5 to 2.1 m faces in Pit Nos. 7 and 29 exposed silty fine sand to fine gravel. Augering in the undeveloped areas uncovered 1 m of gravelly sand to coarse gravel. The deposits are well suited for the extraction of granular subbase.

Four ice-contact/subaqueous fan deposits, located in the western part of Dalton Township and flanking Selected Sand and Gravel Resource Area 1, have also been selected as secondary resource areas. Subsurface data are lacking for these ice-contact/subaqueous fan deposits, although fine to medium sand is exposed at the surface of all of the deposits. Bedrock may be encountered close to the surface in some areas of the deposits. This may be a problem particularly in the northernmost deposit. These deposits are considered to be potential sources of low-specification sand products. Detailed subsurface investigation is recommended prior to extractive development.

Pit Nos. 24 and 11 have been developed in a deposit located along the western boundary of Dalton Township. Test results from a continuation of the deposit in Ramara Township indicate a variable coarse content ranging from 0.6 to 40% (Rowell 1994). Although the deposit has a high percentage of fines with selective handling, good quality material could be extracted.

Two subaqueous fan deposits in southeastern Dalton Township have been designated as secondary resources. Pit Nos. 25, 26 and 27 expose a variety of sediments ranging from fine sand to coarse gravel. The deposits are primarily sources of sand suitable for use as SSM only. In these deposits, consideration must be given to the possible presence of frequent silt seams and a high water table. Similar to other subaqueous fans in the report area, there is potential for encountering gravel at depth. Coarser material may also occur close to bedrock outcrops, as is the situation in Pit Nos. 25 and 26.

Two esker deposits, one located in southwestern Laxton Township and the other in northwestern Bexley Township, have been selected as an aggregate resource area of secondary significance. A 1 m deep test pit, excavated into the crest of this 1.5 to 3 m high ridge, uncovered slightly dirty, coarse gravel with abundant oversize material. This feature appears suitable for small-scale pit development for the extraction of low-specification granular products.

A glaciolacustrine beach deposit located in the southwestern corner of Carden Township has been designated as a secondary resource. Pit Nos. 53, 54 and 55 have been developed in the deposit. Faces in the pits range from 2 to 5 m and expose well-stratified sand and gravel consisting of up to 90% crushable gravel in some places. The best crushing prospects are in the central portion of the beach ridge where the existing pits are located. On the flanks of the ridge, the aggregate is much finer and the material may not be suitable for crushing. The material in the pit areas has been used for a wide range of products including Granular A, subbase and hot-laid asphaltic stone. For Granular M, oversize material must be removed or crushed. The pits are nearing depletion, however, test holes excavated by the MTO in the deposit indicate up to 5 m of gravel in places. In the northwestern portion of the deposit, MTO encountered bedrock between 1 and 3 m below the surface as well as dirty sections. MTO expected the material to the south to be cleaner, deeper and have more potential for crushing. Any further development would have to take into consideration the variable depth of the material and the necessity for selective extraction.

The southern extension of Selected Sand and Gravel Resource Area 3, located on the boundary between Laxton and Bexley townships, has also been selected as a secondary resource. This ice-contact/subaqueous fan deposit is shallower than selected area 3 and bedrock is exposed at Pit No. 48. The area could still supply limited quantities of low-specification aggregate material.

An ice-contact deposit in southwestern Somerville Township contains material suitable for the production of granular subbase and may be suitable for crushing if selective extraction methods are employed. Pit No. 103 has 3 to 5 m faces that expose fine to coarse gravel lenses less than 1.5 m thick, generally overlying fine to medium sand. A sample of one of these gravel lenses contained 47% gravel, 51% sand and 2% fines (Ontario Geological Survey 1992a).

An ice-contact deposit located in the southwestern part of Somerville Township is designated as a secondary resource. Pit No. 106 had 2 to 3 m high faces of mainly fine to coarse gravel with silty pockets. MTO has excavated 14 test holes in the area that revealed primarily sand with large pockets of gravel and/or till. Selective extraction would be necessary for the production of coarse aggregate. Any oversize material would need to be removed or crushed.

Pit Nos. 107 and 108 have been developed in another ice-contact deposit located in the southern part of Somerville Township and the northern part of Fenelon and Veru-

lam townships. Fine to coarse gravel is the primary material exposed in the 3 to 5 m face of Pit No. 107. A 0.3 m thick clay lense is also evident in this pit. The 3 to 4 m faces of Pit No. 108 exposed mainly sand with some gravel. Selective extraction of the material in this deposit may significantly raise the quality of the aggregate extracted.

Map 1B

Three segments of a linear ice-contact stratified drift deposit, located in central Eldon Township near the community of Argyle, have been selected as areas of secondary significance. The deposits have low relief and rolling to slightly hummocky topography. Two pits, Pit Nos. 138 and 139, have been developed in the selected area. A 3 to 6 m face exposes sandy ice-contact stratified drift, similar to that found in Selected Sand and Gravel Resource Area 8. Water well data near Argyle confirm a significant thickness of sand.

An ice-contact/esker complex extends northeastward from Selected Sand and Gravel Resource Area 10. The esker segment contains 2 pits (Pit Nos. 124 and 125) with 3 to 20 m faces exposing primarily sand. A sample (VC-SS-1) taken from a roadcut to the south of Pit No. 125 is suitable for Granular B (Figures 3A and 3B), however, a high PN value precludes its use for hot-laid and concrete products. Test holes excavated by MTO in the vicinity of Pit No. 124 and in the northeastern portion of the ice-contact deposit revealed primarily sand with minor amounts of gravel. The esker segment of this complex has the potential to contain coarser aggregate than the surrounding ice-contact deposit, but an extensive site investigation would be required prior to development.

Two small esker deposits located in or near the village of Woodville in southwestern Eldon Township and northwestern Mariposa Township have been designated as resources of secondary significance. One licenced pit, Pit No. 129, has been developed in the deposit. The 2 to 3 m faces of the pit expose poorly sorted sandy gravel. The presence of very thin silty clay layers may affect the quality of the aggregate in this pit. Similar material was removed from Pit No. 215 in Mariposa Township. The material in these deposits is expected to be suitable for low-specification aggregate and possibly some crushed products but further testing is necessary.

A large ice-contact deposit in the southwestern part of Fenelon Township and the southeastern part of Eldon Township is a resource area of secondary significance. Subsurface information for this deposit is provided by Pit No. 160 and other test holes excavated by the MTO in Fenelon Township. The test holes revealed primarily fine sand resources with isolated pockets of gravel. Further subsurface investigation and testing would be recommended prior to extractive development.

An ice-contact stratified drift deposit located in the central part of Fenelon Township has been selected at the secondary level of importance. Subsurface information for this deposit is limited but it is expected to contain small resources of sand and gravel. Pit No. 153 exposed 3 to 5 m of primarily gravel material.

An outwash deposit located on the north shore of Sturgeon Lake in western Verulam Township has been selected as a sand and gravel resource area of secondary significance. Although most of the deposit is unavailable for extraction due to the heavy concentration of roads and houses in the area, one licenced pit (Pit No. 172) has been developed in the central portion of the deposit. Faces in this pit are 3 to 8 m high and expose primarily well-sorted gravel. A sample taken from this pit met MTO criteria for Granular B (Figures 4a and 4b).

The ice-contact deposits flanking and located to the north of Selected Sand and Gravel Resource Area 16 in Mariposa Township have been selected at the secondary level of significance. The deposit is expected be similar to the sandier parts of resource area 16 and consist of generally less than 6 m of gravelly sand. Pit Nos. 209, 218, 219 and 220 have been developed in the larger ice-contact deposit.

Also, in Mariposa Township, several smaller ice-contact and esker deposits have been designated as secondary resource areas. Subsurface information for the deposits is limited but they are expected to contain sand and gravel resources which can provide good quality material for local projects. Two pits (Pit Nos. 211 and 221) have been opened in 2 esker segments in the eastern portion of the township. These pits expose 2 to 4 m of primarily gravel material. MTO information for the easternmost of these 2 deposits revealed at least 2 m of sand and gravel. The gravel is suitable for crushing, however, oversize material must be removed or crushed. Pit No. 222 has been developed in an esker deposit along the west side of the township. Historical MTO information for this pit indicated the presence of material similar to that found in Pit Nos. 211 and 221. Pit Nos. 224 and 225 have been opened in other small ice-contact deposits. Further testing of these deposits would be necessary before any extractive development was undertaken.

Two small eskers, which trend along the west bank of the Scugog River in Ops Township, have been selected as resource areas of secondary importance. The ridges are approximately 5 to 6 m high and the faces of Pit No. 235 exposed poorly to moderately sorted gravel, similar to that found in Selected Sand and Gravel Resource Area 18. The gravel is suited for a variety of road building and construction aggregates, although clay seams and clay coatings reduce the usefulness of the material.

Two small esker segments in east-central Emily Township, have been designated as areas of secondary importance. Pit No. 280 is located in the northern most deposit and face heights indicated the presence of 2 to 4 m of coarse aggregate.

Two ice-contact/esker deposits in southeastern Emily Township near Fowlers Corners have also been chosen as secondary resourse areas. Four pits are located in the deposits, however, Pit No. 282 has been rehabilitated. The faces in these pits range from 3 to 9 m and expose aggregate similar in texture to that found in Selected Sand and Gravel Resource Area 21. Test holes excavated by MTO in

the southern deposit and to the south of Pit No. 281 revealed generally more than 3 m of sand with minor amounts of gravel. Water was also encountered in several of the holes, from 1.5 to 3 m below the surface. Selective extraction and sand control may be required to produce crushed aggregate products. In some locations, oversize material must be removed before crushing. The fine fraction of the aggregate often contains excess fine-grained material and is occasionally too dirty for any granular use.

Another ice-contact/esker complex near Keneden Park in central Emily Township has been designated as an area of secondary significance. MTO information for a part of this deposit indicates the presence of gravel suitable for crushing. Samples of the sand were generally too fine, too coarse or too dirty for hot-laid asphaltic products. Petrographic numbers for some of the samples were too high to use the aggregate for hot-laid and concrete products. This deposit has the potential to produce some high- and low-specification products for the local market.

North of Downeyville in Emily Township is an outwash deposit selected at the secondary level of significance. Very little information on the depth or quality of the material is available. One water well in the deposit indicates granular material to a depth of 15 m. Further investigation is strongly recommended prior to undertaking before any extractive activity.

A sandy ice-contact stratified drift deposit which flanks the eastern portion of Selected Sand and Gravel Resource Area 19 in Emily Township has been designated as a resource area of secondary importance. Data are scarce for this deposit but possible resources of fine material suitable for hot-laid asphaltic aggregate may be present.

To the east, west and north of Selected Sand and Gravel Resource Area 24 in Manvers Township are a series of large ice-contact stratified drift deposits. These deposits have been designated as areas of secondary significance. The areas, although extremely irregular and hummocky, are characterized by topography lower than that of resource area 24. MTO information indicates a predominance of sand with minor pockets of gravel. In the vicinity of Pit No. 291, coarse granular material is found in low irregular ridges with intervening lenses of sand and till. A sample collected in a similar area in the Regional Municipality of Durham indicated 14% coarse aggregate material. Further field investigation is recommended before any extractive development is initiated.

BEDROCK GEOLOGY AND RESOURCE POTENTIAL

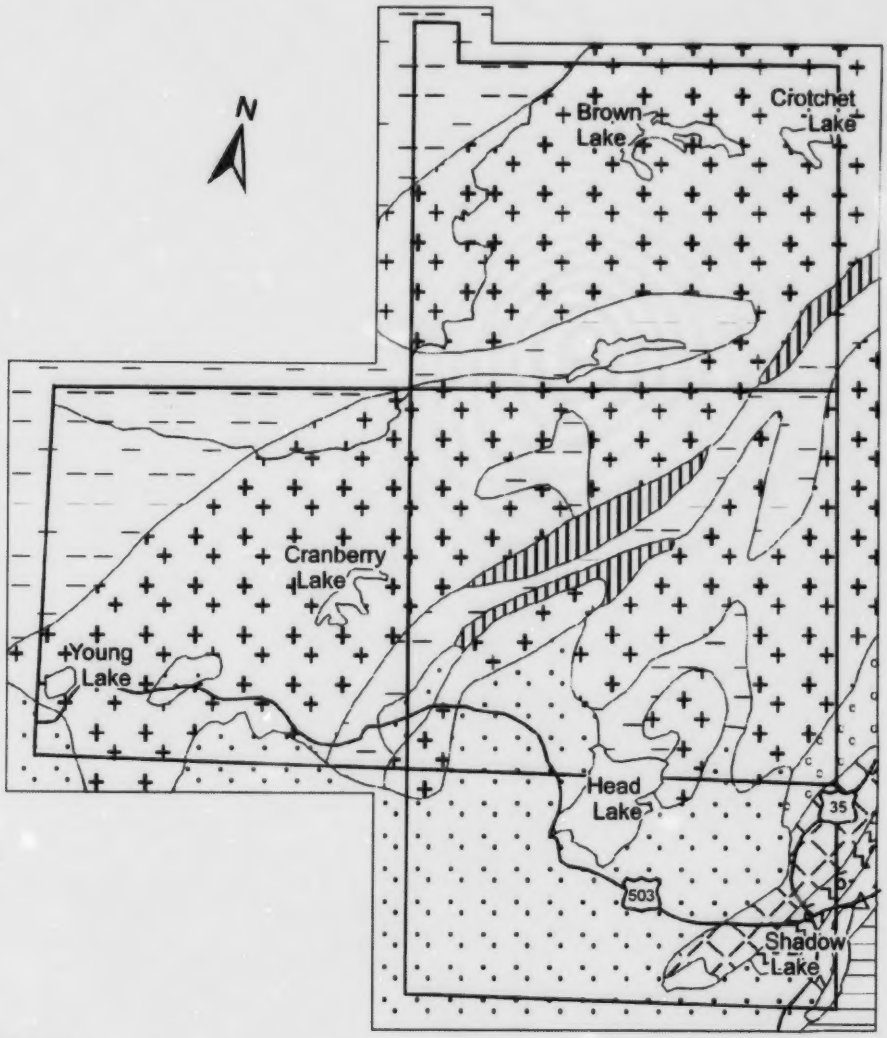
The oldest bedrock in the county is the Precambrian-aged rocks of the Central Gneiss Belt, Central Metasedimentary Belt, Central Metasedimentary Belt Boundary Zone and the Glamorgan Gneiss Complex of the Canadian Shield (Wynne-Edwards 1972, Easton 1988). These metamorphic and igneous rocks underlie the northern part of the report area. Geological mapping by Easton and Bartlett (1984); Easton et al. (1985a, 1985b); Easton et al. (1987); Easton (1987, 1988) and the Ontario Geological Survey (1991) covers the area. The Precambrian rocks consist predominantly of felsic igneous rocks (gneisses, amphibolites and migmatitic rocks, syenogranite and tonalite) and clastic and carbonate metasedimentary rocks with minor tectonite and anorthosite (Figure 2).

The Precambrian bedrock may exhibit wide variations with respect to aggregate quality over relatively short distances. Highly weathered, brittle and friable Precambrian bedrock, which is unacceptable for aggregate use, may occur within the report area. There are also many areas underlain by more massive, hard and durable rock that appears suitable for a variety of aggregate applications. However, some of the massive, coarse-grained felsic igneous rocks and gneisses with high mica, feldspar and quartz contents may have bonding problems because the smooth cleavage and fracture surfaces of these minerals hinder the adhesion of asphalt and cement mixes. This problem may be circumvented by weathering the rocks for a period of time in stockpiles or by adding chemicals (anti-stripping agents) which erode the smooth surfaces and allow better adhesion. Rogers (1985) reports that some granitic rocks can slowly react with the alkalies from Portland cement concrete, resulting in concrete deterioration.

No specific areas of Precambrian bedrock have been selected for possible resource protection because Paleozoic bedrock is considered the preferred source of bedrock-derived aggregate in the area. The Precambrian rock is generally more variable and difficult to process than the Paleozoic strata. If large scale road building or construction projects are undertaken in the northern part of the report area, the Precambrian bedrock should be considered as a potential aggregate source. There is considerable latitude for choosing sites for extraction of Precambrian rock as bedrock is close to the surface throughout much of the northern area. Any site proposed for quarry development should be tested in detail before extraction occurs. Quarry No. 2 in Laxton Township is excavating Precambrian rock.

Maps 2A and 2B depict the Paleozoic geology of Victoria County. These maps are based on previously published ARIP maps (Ontario Geological Survey 1980a-f, 1981a, 1981b, 1981c, 1992a, 1992b), recent Paleozoic geology maps (Armstrong and Anastas 1993, Armstrong and Rheaume 1994) and unpublished information. During the Paleozoic Era, a succession of sedimentary rocks were deposited in the shallow seas which covered Victoria County. These rocks underlie the vast majority of the county. The oldest Paleozoic bedrock exposed in the county, the Shadow Lake Formation, was deposited in a nearshore environment over an undulating Precambrian surface. The soft and friable shales, siltstones, sandstones and conglomerates of the Shadow Lake Formation are unsuitable for most aggregate uses.

The Gull River Formation consists of green to grey to brown lithographic to sublithographic, fine-grained to microcrystalline, thin-bedded to massive, limestone, dolomitic limestone and dolostone. The Gull River Formation generally ranges from 21 to 24 m thick (Liberty 1969). In the study area, the limestone of this formation is generally



LEGEND

PALEOZOIC

Limestone, dolostone shale, sandstone

PRECAMBRIAN

Tectonite unit

Early felsic plutonic rocks

Carbonate metasedimentary rocks

Clastic metasedimentary rocks

Mafic to felsic meta-volcanic rocks

Felsic igneous rocks

Anorthosite and alkalic igneous rocks

Migmatic rocks and gneisses of undetermined

Figure 2. Bedrock geology of Laxton, Digby and Longford and Dalton townships, scale 1:240 000 [after Ontario Geological Survey (1991)].

suitable for a wide range of crushed stone products (Derry Michener Booth and Wahl and Ontario Geological Survey 1989a, 1989b). For this reason, areas underlain by the Gull River Formation with thin drift cover (less than 8 m) have been selected for possible resource protection. Two exceptions are the 2 outliers in Dalton Township which have not been selected since the formation in these areas is expected to be relatively thin.

Crushed stone from the Gull River Formation is extracted for a variety of aggregate uses in southern Ontario, including concrete, asphalt and granular base. Testing of the rock is necessary because certain beds within the formation are chemically reactive with Portland cement mixes (Rogers 1985). This reaction, an alkali–carbonate reaction, can result in the deterioration of concrete structures subject to moist environments and/or road salts. Alkali–carbonate reactive beds cannot be readily identified through visual examination in the field. They can be identified by subjecting the rock to concrete expansion testing, microscopic examination and/or chemical analysis (Rogers 1985). Recent testing of drill cores (Armstrong 1995) indicates that alkali–reactive beds tend to occur in the lower part of the formation. Selective extraction of the non-reactive beds may, therefore, be required for the production of some concrete aggregates. The Gull River Formation bedrock is generally well suited for use as hot–laid asphalt, but polishing of the stone may be a problem if the rock is used in asphaltic surface course. Beds of shaly, silty to sandy dolostone may require blending with the surrounding, more competent, bedrock units for the production of granular base. Similarly, beds of calcitic dolostone at the base of the formation may only be suitable for granular base.

The limestones of the Bobcaygeon Formation overlie the Gull River Formation. The lower member of the Bobcaygeon Formation consists predominantly of thick-bedded, grey and brownish grey, microcrystalline to fine-crystalline limestone with medium- to coarse-grained calcarenite layers. The middle and upper members consist of grey, thin- to thick-bedded, very fine- to medium-grained limestone with medium- to coarse-grained calcarenitic limestone layers. The middle member has a higher shale content than either the lower or upper members (Liberty 1969; Derry Michener Booth and Wahl and Ontario Geological Survey 1989b). The Bobcaygeon Formation is estimated to be approximately 24 m thick in the study area (Liberty 1969). The Bobcaygeon Formation is a major aggregate source in south-central and southeastern Ontario. Areas of the Bobcaygeon Formation with less than 8 m of drift cover have been selected for resource protection. A few islands and Balsam Lake Provincial Park have not been selected due to cultural constraints.

Similar to the Gull River Formation, certain beds within the Bobcaygeon Formation may be alkali–reactive. In this case, an alkali–silica reaction occurs between Portland cement and the silica–bearing rocks. Beds within the Bobcaygeon Formation found to be reactive usually contain less than 3% black chert along with microscopic chalcedony (Rogers 1985). The more shaly, middle parts of the formation may not be as suitable for the production of concrete aggregates as the surrounding strata (Ontario Geological Survey 1992b). Therefore, selective extraction measures may be required for the production of concrete aggregates within the formation. The formation is generally well suited for most other aggregate uses including asphaltic stone and granular base.

Overlying the Bobcaygeon Formation is the Verulam Formation. This formation consists predominantly of alternating layers of grey to brownish grey, fine- to medium-grained argillaceous and sublithographic limestone with greenish grey shale. The thickness of this formation can reach approximately 61 m (Liberty 1969). This formation has been quarried for lime and the manufacture of cement in other parts of the province, but the stone has a low resistance to abrasion that diminishes its suitability for road building and construction aggregates. For this reason, areas underlain by the Verulam Formation have not been selected for resource protection.

The Lindsay Formation overlies the Verulam Formation in the southern part of the county. This formation can be subdivided into upper and lower members. The lower member consists of very fine- to coarse-crystalline, commonly nodular, argillaceous limestones. The upper member, the Collingwood Member, consists of a black, petroliferous, argillaceous limestone. This member was originally the lower member of the Whitby Formation but Russell and Telford (1983) reassigned it to the upper member of the Lindsay Formation and renamed the remainder of the Whitby Formation, the Blue Mountain Formation. The limestones of the Lindsay Formation have been used for the manufacture of cement but are unsuitable for concrete because of a generally high clay content and expansive properties. The Lindsay Formation is quarried south of Victoria County in the Bowmanville area by Blue Circle Aggregates for production of cement. Quarry Q23 in Mariposa Township exposes the Lindsay Formation.

SELECTED BEDROCK RESOURCE AREAS

Areas of the Gull River and Bobcaygeon formations that are overlain by less than 8 m of drift have been selected for resource protection. Both of these formations have been traditional sources of road building and construction aggregate for southern Ontario. Selected Bedrock Resource Areas 1 and 2 occur in parts of Dalton, Digby, Laxton, Carden, Bexley, Somerville, Eldon, Fenelon and Verulam townships. These resource areas represent an extremely large area with the potential to supply aggregate locally and regionally. Site specific investigations are necessary to determine the potential uses of the rock in that specific area. The Selected Bedrock Resource Areas occupy a possible resource area of 50 747 ha and contain resources of 24 199 million tonnes (Table 6). **The above figures represent a comprehensive inventory of all areas with less than 8 m of overburden overlying these formations. Other planning issues and constraints may prevent site development in these selected bedrock resource areas.**

Selected Bedrock Resource Area 1

Selected Bedrock Resource Area 1 consists of most of the areas where the Gull River Formation is covered by less than 8 m of drift. This resource area covers a portion of Dalton, Digby, Laxton, Carden, Bexley and Somerville townships.

Eight quarries have been developed in bedrock resource area 1. In Quarry Nos. 4, 5, 6, 14, 16, 17, 18 and 19, beds of limestone have been extracted for use as flagstone and/or road building and construction aggregate. The primary activity in these quarries is the production of flagstone. A sample of the limestone from Quarry No. 18 was submitted for 3 aggregate quality tests. Results of these tests suggest that the stone is suitable for a wide range of aggregate products except for HL1 asphalt (Table 9). This quarry is abandoned now but has supplied building and crushed stone since the turn of the century (Parks 1912).

MTO have tested drill core from several holes in Somerville Township and one in Carden Township. The results of these tests indicate that some sections of the formation are better suited for high-specification aggregate uses than others. The shaly limestone of the upper member of the Gull River Formation is generally only suitable for granular base. The calcitic dolostone and dolomitic limestone of the lower member of the Gull River Formation are generally suitable for all uses except surface paving on high-traffic roadways. However, where this rock is silty or sandy, aggregate uses are limited to granular base. It should be tested for alkali-carbonate and alkali-silica reactions. Gypsum was also found in these cores. If it is present in quantities greater than approximately 1%, it could cause problems with sulphate expansion in concrete. In general, the Gull River Formation represents a potential source of concrete, asphaltic and granular base aggregates; however, selective extraction is required for the production of aggregate for concrete and hot-laid asphalt.

Steep escarpments, ranging in height from 7 to more than 15 m, often mark the contact of the Paleozoic with the Precambrian rock. In these escarpments, between 3 and 15 m of the Gull River Formation strata may overlie the Shadow Lake Formation. Away from the escarpments, the Gull River Formation generally increases in thickness in a southwesterly direction to about 24 m near the Bobcaygeon-Gull River formation boundary. Although areas of the Gull River Formation along the Paleozoic-Precambrian boundary and the Shadow Lake-Gull River formation boundary have been selected for resource protection, the thickness of the Gull River Formation in these areas will be considerably less than 18 m.

Selected Bedrock Resource Area 1 occupies 10 862 ha of which 9132 ha are available for extraction. Although the thickness of the Gull River Formation strata can vary from 3 to 24 m, the tonnage values have been calculated using a thickness of 18 m which is considered the average thickness of the formation in area 1. Possible bedrock resources are estimated to be 4355 million tonnes in Selected Bedrock Resource Area 1 (Table 6). The area is accessible by various highways and township roads.

Selected Bedrock Resource Area 2

Selected Bedrock Resource Area 2 is located in parts of Digby, Dalton, Laxton, Carden, Bexley, Somerville, Eldon, Fenelon and Verulam townships. This resource area consists of areas of Bobcaygeon Formation that have an overlying drift thickness of 0 to 8 m. The limestone of the Bobcaygeon Formation can be as much as 24 m thick in the region (Liberty 1969) and the thickness generally increases towards the southwest, away from the Bobcaygeon-Gull River boundary. In areas close to the boundary, it may be possible to extract the underlying Gull River Formation strata along with the Bobcaygeon Formation limestone. Large areas of thinly drift-covered Bobcaygeon Formation occur in Carden Township. This feature, known as the Carden Plain (Chapman and Putnam 1984), is not heavily populated and has the potential to produce large quantities of aggregate.

At present, there are 5 licenced quarries developed in Selected Bedrock Resource Area 2. Quarry No. 13 in Somerville Township and Quarry Nos. 7 and 10 in Carden Township primarily supply crushed stone for road building and construction. Quarry No. 8 in Carden Township also crushes stone from the Bobcaygeon Formation as there is only 3 m of the Verulam Formation overlying the Bobcaygeon Formation at this site. Quarry No. 8, in particular, has produced stone to supply the eastern region of the Greater Toronto Area. A small unlicenced quarry is located in each of Bexley, Eldon and Verulam townships. Quarry No. 1 in Laxton Township was extracting flagstone at the time of writing.

The MTO drill holes, mentioned in the Selected Bedrock Resource Area 1, also encountered the Bobcaygeon Formation. The shaly limestone of the middle Bobcaygeon Formation has the potential to produce HL4. The limestone of the lower Bobcaygeon Formation is suitable for all aggregate uses except for surface paving on high-traffic roads. These rocks also require testing for alkali-silica reactivity.

The Bobcaygeon Formation is generally suitable for uses including hot-laid asphalt, granular base and surface treatment aggregates. Selective extraction may be required for the production of concrete aggregate. Those areas overlain by less than 1 m of drift are considered to have the highest potential within Selected Bedrock Resource Area 2.

Selected Bedrock Resource Area 2 occupies approximately 47 929 ha of which 41 615 ha are available for extraction. Assuming an average bedrock thickness of 18 m, possible bedrock resources are estimated to be approximately 19 844 million tonnes (Table 6). Access to resource area 2 is possible via highways, as well as township roads.

CHART C - BEDROCK RESOURCES SUMMARY
VICTORIA COUNTY

Formation	Rock Type	Approximate Thickness (m)	Aggregate Suitability	Other Uses	Occurrence	Notes
Lindsay	Lower member is interbedded, fine- to coarse-grained limestone with shaly partings. Upper member is interbedded, dark grey shale with petroliferous limestones.	25 to 65	Restricted	Manufacture of cement	Occurs in the southern portion of Victoria County. Very little of the Lindsay Formation outcrops in the county.	Has been used for aggregate in eastern Ontario. In central Ontario, the Lindsay Formation has been used in the production of cement. Maybe suitable for use as concrete and asphalt aggregate.
Verulam	Fossiliferous, pure to argillaceous limestone interbedded with calcareous shale.	30 to 65	Restricted	Manufacture of cement	Occurs in a east-west band just north of the Lindsay Formation in central Victoria County. There is not extensive outcropping of the Verulam.	Has been used for aggregate elsewhere in the Province. Can be used in the manufacture of cement. May be unsuitable for use as aggregate in some areas because of its high shale content.
Bobcaygeon	Subdivided into upper, middle and lower members. Homogeneous, massive to thin bedded, fine-crystalline limestone with numerous shaly partings.	5 to 90	Yes	-	Generally located in the central to north central portion of Victoria County. There are areas of extensive outcropping.	Quarried throughout Ontario for use as granular base course and for use in asphalt and concrete. Certain layers are alkali-silica reactive when used in Portland cement concrete.
Gull River	Lower member alternating units of limestone, dolomitic limestone and dolostone. Upper member is thin-bedded limestone and shales.	7 to 135	Yes	-	Located in the northern part of Victoria County. There are large areas of outcropping or where overburden in thin.	Quarried throughout Ontario for crushed stone. Certain layers have proven to be alkali-carbonate reactive when used in Portland cement concrete.
Shadow Lake	Soft and friable shales, siltstone, sandstone and conglomerate.	0 to 3	No	-	Located in the northern part of Victoria County, generally just south of the Precambrian-aged rocks.	This formation is not suitable for aggregate use and has little potential for other uses.

SUMMARY

Sand and gravel deposits in Victoria County are the product of glacial processes which took place during the Late Wisconsinan Substage of the Pleistocene Epoch. A number of these deposits, which contain significant resources of sand and gravel, have been grouped together into 24 primary resource areas. In addition, numerous deposits, which add to the area's resource base, have been selected at the secondary level of significance.

Most of the sand and gravel resources are available from ice-contact, subaqueous fans and esker deposits. The quality of the aggregate within the deposits is generally variable but with selective extraction and blending, these deposits are capable of producing a wide range of aggregate products. The northern part of the township has sand and gravel resources which are generally limited in size and quality. Bedrock resources play a more significant role in this area.

The report area is underlain by both Precambrian and Paleozoic bedrock. Seventeen quarries have been developed in the Paleozoic limestones of the Gull River and Bobcaygeon formations. These formations have been selected as bedrock resource areas where the drift cover is less than 8 m thick. These areas represent the most valuable source of crushed stone in the county. Crushed stone from these formations is generally suitable for a wide range of aggregate products, however, certain beds of the formations have the potential to be alkali-reactive and, for this reason, MTO may not accept them in concrete aggregate (Rogers 1985).

Enquiries regarding the Aggregate Resources Inventory of Victoria County should be directed to the Sedimentary Geoscience Section, Ontario Geological Survey, 933 Ramsey Lake Road, 7th Floor, Sudbury, Ontario, P3E 6B5; or to the Staff Geologist, Ministry of Northern Development and Mines, Macdonald Block, Queen's Park, 900 Bay Street, Toronto, Ontario, M7A 1C3; or to the Ministry of Natural Resources, Peterborough and Minden Area Offices.

TABLE 1 – TOTAL SAND AND GRAVEL RESOURCES VICTORIA COUNTY			
1 Class No.	2 Deposit Type	3 Areal Extent (Hectares)	4 Original Tonnage (Million Tonnes)*
LONGFORD TOWNSHIP			
2	S–OW.LP	34	2.7
3	G–IC	3	0.1
	G–OW	5	0.2
	G–OW.LP	3	0.1
	S–IC	8	0.3
	S–IC.LD	11	0.4
	S–OW.LP	49	1.7
4	G–OW.LP	3	<0.1
	S–AL	308	5.5
	S–IC	3	<0.1
	S–LP	499	8.8
	S–OW.LP	137	2.4
Subtotal		**1063**	**22.2**
DALTON TOWNSHIP			
1	G–IC	6	0.6
	S–IC.SF	28	3.0
2	S–IC.SF	255	20.3
	S–SF	38	3.0
3	S–IC.SF	99	3.5
	S–LP	167	5.9
	S–LP.SF	29	1.0
	S–OW.LP	6	0.2
	S–SF	20	0.7
4	G–LB	9	0.2
	S–IC.SF	17	0.3
	S–LP	1404	24.9
	S–SF	25	0.4
Subtotal		**2103**	**64.0**
DIGBY TOWNSHIP			
3	G–IC	4	0.1
4	G–LB	5	0.1
	S–LP	114	2.0
Subtotal		**123**	**2.2**
LAXTON TOWNSHIP			
2	G–OW	8	0.6
	S–IC.SF	285	22.7
	S–SF	7	0.6
3	G–OW	25	0.9
	G–E	39	1.4
	G–IC.SF	7	0.2
	S–SF	20	0.7

TABLE 1 - TOTAL SAND AND GRAVEL RESOURCES VICTORIA COUNTY			
1 Class No.	**2 Deposit Type**	**3 Areal Extent (Hectares)**	**4 Original Tonnage (Million Tonnes)***
4	G-IC	5	<0.1
	S-LP	1210	21.4
Subtotal		**1606**	**48.5**
CARDEN TOWNSHIP			
2	G-OW	110	8.8
	G-E	36	2.9
	G-LB	41	3.3
	S-LP	293	23.3
3	G-OW	23	0.8
	G-E	25	0.9
	G-IC	96	3.4
	G-LB	30	1.1
	S-LP	475	16.8
4	G-LB	81	1.4
	S-LB	4	<0.1
	S-LP	331	5.9
Subtotal		**1545**	**68.6**
BEXLEY TOWNSHIP			
1	G-E	77	8.2
2	G-E	114	9.1
	S-LP	109	8.7
3	G-E	78	2.8
	G-IC.SF	36	1.3
	S-IC	5	0.2
	S-LP	1070	37.9
4	G-LB	10	0.2
Subtotal		**1499**	**68.4**
SOMERVILLE TOWNSHIP			
2	G-IC	11	0.9
	S-IC	50	4.0
	S-LP.OW	388	30.9
3	G-E	4	0.1
	S-E	18	0.6
	S-IC	85	3.0
	S-LP.OW	1267	44.9
	S-OW	419	14.8
4	S-IC	41	0.7
	S-LP	178	3.2
	S-LP.OW	1570	27.8
	S-OW	585	10.4
Subtotal		**4616**	**141.3**

TABLE 1 - TOTAL SAND AND GRAVEL RESOURCES VICTORIA COUNTY			
1 Class No.	2 Deposit Type	3 Areal Extent (Hectares)	4 Original Tonnage (Million Tonnes)*
ELDON TOWNSHIP			
1	G-E	76	8.1
	G-IC	543	57.7
	S-IC	116	12.3
2	G-E	76	6.1
	G-IC	166	13.2
	S-IC	424	33.8
	S-LP	268	21.3
3	G-E	52	1.8
	G-IC	236	8.4
	G-LB	106	3.8
	S-IC	126	4.5
	S-LB	54	1.9
	S-LP	1907	67.5
4	G-LB	21	0.4
	S-IC	415	7.3
	S-LB	62	1.1
	S-LP	12	0.2
Subtotal		**4660**	**249.4**
FENELON TOWNSHIP			
1	G-E	382	40.6
	G-IC	827	87.8
	G-OW	61	6.5
2	G-IC	663	52.8
	G-LB	32	2.5
	G-OW	76	6.1
	S-IC	141	11.2
	S-OW	72	5.7
	S-LP	145	11.5
3	G-IC	438	15.5
	S-LB	35	1.2
	S-OW	86	3.0
	S-LP	640	22.7
4	G-IC	60	1.1
	G-LB	22	0.4
	S-LP	606	10.7
	S-OW	410	7.3
Subtotal		**4696**	**286.6**
VERULAM TOWNSHIP			
1	G-E	79	8.4
	G-IC	148	15.7
	G-OW	188	20.0
2	G-E	61	4.9
	G-IC	289	23.0

TABLE 1 - TOTAL SAND AND GRAVEL RESOURCES
VICTORIA COUNTY

1 Class No.	2 Deposit Type	3 Areal Extent (Hectares)	4 Original Tonnage (Million Tonnes)*
2	S-OW	24	1.9
	S-LP	32	2.5
	S-IC	4	0.3
3	G-E	17	0.6
	G-IC	58	2.1
	G-OW	88	3.1
	G-LB	4	0.1
	S-OW	401	14.2
	S-LP	26	0.9
	S-IC	13	0.5
4	S-IC	82	1.5
	S-LP.OW	4	<0.1
	S-LP	143	2.5
Subtotal		**1661**	**102.2**
MARIPOSA TOWNSHIP			
1	G-E	17	1.8
2	G-E	475	37.8
	G-IC	23	1.8
	S-IC	345	27.5
3	G-E	60	2.1
	G-IC	92	3.3
	S-IC	508	18.0
	S-LP	138	4.9
4	G-E	12	0.2
	G-IC	382	6.8
	S-LP	2186	38.7
Subtotal		**4238**	**142.9**
OPS TOWNSHIP			
2	G-E	186	14.8
	S-LP	29	2.3
3	G-E	62	2.2
	S-LP	50	1.8
4	G-E	52	0.9
	S-LP	2815	49.8
	S-IC	72	1.3
	S-OW	25	0.4
Subtotal		**3291**	**73.5**
EMILY TOWNSHIP			
1	G-E	377	40.0
	G-IC	1602	170.1
	S-IC	197	20.9
2	G-IC	315	25.1
	G-IC.E	347	27.6
	S-OW	355	28.3

TABLE 1 - TOTAL SAND AND GRAVEL RESOURCES
VICTORIA COUNTY

1 Class No.	2 Deposit Type	3 Areal Extent (Hectares)	4 Original Tonnage (Million Tonnes)*
3	G-E	30	1.1
	G-IC	81	2.9
	S-IC	10	0.4
	S-OW	2860	101.2
4	G-E	23	0.4
	G-IC	21	0.4
	S-IC	27	0.5
	S-LP	2992	53.0
	S-OW	21	0.4
Subtotal		**9258**	**472.3**
MANVERS TOWNSHIP			
1	G-IC.E	100	10.6
	G-IC	519	55.1
	G-M	2202	233.9
	S-IC	972	103.2
	S-LP	1797	190.8
	S-M	2423	257.3
2	G-IC.E	298	23.7
	S-IC	362	28.8
	S-LP	5335	424.9
	S-M	549	43.7
3	S-LP	305	10.8
Subtotal		**14862**	**1382.8**
COUNTY TOTAL		**55221**	**3124.9**

* Minor variations in all tables are caused by the rounding of data.

The above figures represent a comprehensive inventory of all granular materials in the map area. Some of the material included in the estimate has no aggregate potential and some is unavailable for extraction due to land use restrictions.

TABLE 2 - SAND AND GRAVEL PITS
VICTORIA COUNTY

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
LONGFORD TOWNSHIP					
Unlicenced Pits					
1	-	-	0.9–1.2	-	fine to medium sand flanking rock
2	-	-	0.9	-	medium sand, water on pit floor
3	-	-	4.6	15	1.2 m of fine to coarse gravel over 0.3 m of silty fine sand over 3.0 m of medium sand
4	-	-	2.4	50–60	sandy fine gravel
5	-	-	-	-	partially rehabilitated
6	-	-	1.5	10–50	ranges from medium sand to sandy fine gravel
7	-	-	1.5–2.1	0–30	variable material ranging from silty fine sand to fine gravel
8	-	-	0.9	30	gravelly medium to coarse sand which becomes finer at depth
9	-	-	0.9–1.5	0–5	clean medium sand
DALTON TOWNSHIP					
Licenced Pits					
10	Keith Smith Contracting	5.00	1.5	30	coarse sand and fine gravel
11	V.R. Cathcart	9.00	3.0–5.5	0–5	fine to medium sand, silt seams, gravel once extracted from below water table
Unlicenced Pits					
12	-	-	1.5–3.0	10–50	variable from fine gravel to fine sand with silt seams, bedrock exposed in pit floor
13	-	-	1.5	30–40	1.5 m of gravelly sand, medium sand in pit floor
14	-	-	2.4	40	0.6 to 1.2 m of fine to coarse gravel over gravelly sand
15	-	-	4.6	30–65	variable from sand to coarse gravel
16	-	-	2.4	35–45	sandy fine gravel
17	-	-	3.6	20	gravelly fine to medium sand
18	-	-	1–2	20–25	similar to Pit No. 17, on west side of road
19	-	-	1.2	60–70	fine gravel
20	-	-	3	10–30	0.9 to 1.5 m of silty fine to medium sand over steeply inclined layers of gravelly sand
21	-	-	3	0	slumped sand
22	-	-	3.0–6.1	20–70	variable material ranging from 4.6 m pockets of coarse gravel to silty fine sand
23	-	-	3	0–30	1.2 m of silt and silty fine sand over fine to medium sand, gravel below water table
24	-	-	9.1	0–15	predominantly fine to medium sand, minor pockets of fine gravel
25	-	-	1.5–2.4	0	fine sand with a 0.3 m thick silt seam present
26	-	-	0.9–1.5	10–30	varies from medium to coarse sand to gravel, bedrock in pit floor

TABLE 2 - SAND AND GRAVEL PITS
VICTORIA COUNTY

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
27	-	-	0.9–1.5	20	coarse gravel over coarse sand, bedrock in pit floor
28	-	-	1.5–2.4	60–70	tabular beach gravel over bedrock, oversize clasts present
DIGBY TOWNSHIP					
Unlicenced Pits					
29	-	-	1.5	30–40	0.6 to 0.9 m of fine gravel over clean medium sand
30	-	-	1.2	0	medium sand, water on pit floor
LAXTON TOWNSHIP					
Licenced Pits					
31	D.R. Graham	14.5	3.0–3.6	0	silty fine to medium sand
32	Ingram Wessell and Sons Limited*	23.00	6.1–7.6	<20	overgrown
33	Ingram Wessell and Sons Limited*	17.80	6.1	50–60	fine to coarse gravel, bedrock exposed in one area of pit floor
34	R. Harrison	24.30	1.5	< 5	silty, fine to medium sand
35	Ingram Wessel and Sons Limited	6.00	2.4–5	10–40	1.5 m of silty fine to medium sand over 3.0 m of medium to coarse sand with variable amounts of sandy fine to coarse gravel, some coarse gravel extracted from below the water table
36	Ingram Wessel and Sons Limited	10.30	2.4–6	-	silty fine to medium sand, some coarse gravel extracted from below the water table
37	J. Chynoweth*	9.80	6.0–7.5	variable	mainly silty fine to medium sand, clay in pit floor, <1 m thick layer of coarse gravel at surface
Unlicenced Pits					
38	-	-	3.0–4.6	50–60	variable material, oversize clasts present
39	-	-	1.2		gravel, overgrown, bedrock exposed in pit floor
40	-	-	2.4–4.6	30–45	freshly worked face exposed 0.9 m of gravelly medium sand over 0.9 m of fine gravel over 0.6 m of coarse sand, bedrock exposed in pit floor
41	-	-	1.5–2.4	0	overgrown
42	-	-	3.0–6.1	0–25	3.0 m of silty fine sand with some silt lenses over fine gravelly sand
43	-	-	1.5–6.1	<20	fine to medium sand with minor pockets of gravelly sand, silt seams present, coarse gravel was removed from below water table, bedrock in one face
44	-	-	0.9–1.5	0	sand, overgrown
45	-	-	3.0–4.6	-	overgrown, water on pit floor
46	-	-	7.6	-	rehabilitated
47	-	-	1.5–2.4	30–50	overgrown

TABLE 2 - SAND AND GRAVEL PITS
VICTORIA COUNTY

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
48	-	-	1.5-2.4	40-50	variable material, abundant clasts of poor quality Shadow Lake Formation
CARDEN TOWNSHIP					
Licenced Pits					
49	C. Campbell	14.17	2-4	5	overgrown, water in pit floor
Unlicenced Pits					
50	-	-	2-4	5-10	overgrown
51	-	-	6-9	50-65	
52	-	-	1-2	35-40	
53	-	-	2-4	70-90	
54	-	-	2-5	70-90	nearing depletion
55	-	-	1-2	35-50	overgrown
56	-	-	3-6	40-60	
57	-	-	3-5	35-50	nearing depletion
BEXLEY TOWNSHIP					
Licenced Pits					
58	P.A. Wilcox	14.6	2-3	10	
59	Five W Farms Inc.*	138.2	2-10	variable	clay and silty sand in pit floor
Unlicenced Pits					
60	-	-	2-3	40-60	
61	-	-	6	50-70	
62	-	-	6	60-70	partially overgrown
SOMERVILLE TOWNSHIP					
Licenced Pits					
63	P. Demoe	16.00	2-5	-	fine to coarse sand
64	M.D. Newman	9.70	2-3	-	fine to medium sand
65	Royel Paving Ltd.	8.10	1.5	variable	fine gravel with fine to medium gravel, water in pit floor
66	C. Hodgson	4.80	2-3	-	fine to medium sand, bedrock in pit floor
67	Dudman Construction (1980) Ltd.	23.62	3-11	variable	silty fine sand sections, fine gravel layers <0.6 m thick
68	J. MacDonald	42.40	2-3	variable	bedrock in floor
69	B.C. Wakelin	25.80	5-6	variable	bedrock in floor
70	R.E. Watson	61.10	1.5-2	variable	fine to coarse sand in south faces, fine sand to cobbles in north faces
71	R.P. Wilson	6.80	2	variable	<1 m of gravel over sand, partially overgrown
Unlicenced Pits					
72	-	-	<1.5	-	fine sand, partially overgrown
73	-	-	1-5	-	sand, water on floor, partially overgrown

TABLE 2 - SAND AND GRAVEL PITS VICTORIA COUNTY					
1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
74	-	-	2	-	sand, bedrock in face and floor
75	-	-	2	-	sand, partially overgrown
76	-	-	2	-	fine to medium sand, overgrown
77	-	-	1-5	-	fine sand with silty sections
78	-	-	5	-	fine to medium sand
79	-	-	<1.5	-	medium sand, water on floor
80	-	-	3-8	variable	sand with fine gravel and very fine sand and silt sections, bedrock in face
81	-	-	2	-	sand, partially overgrown
82	-	-	3-5	-	sand
83	-	-	1.5-3	-	sand
84	-	-	2	<10	water on floor, partially overgrown
85	-	-	3-4	-	till
86	-	-	<1.5	-	till, bedrock in floor
87	-	-	<1.5	-	silty sand, overgrown
88	-	-	1.5-3	-	sand, partially overgrown
89	-	-	3-5	<20	medium sand to fine
90	-	-	1-2	<10	fine to medium
91	-	-	2	<5	fine to medium
92	-	-	<1.5	-	fine sand, water on floor
93	-	-	2-3	-	silty fine sand to oversize clasts
94	-	-	<1.5	-	medium sand
95	-	-	1.5-3	<5	partially overgrown
96	-	-	2-3	<20	clean medium to coarse sand
97	-	-	2	-	sand
98	-	-	2-3	<5	fine to medium sand
99	-	-	2-3	variable	water on floor, bedrock in floor
100	-	-	2-3	-	till
101	-	-	2	-	till, overgrown
102	-	-	3	variable	high silt and clay content
103	-	-	3-5	variable	fine to medium sand with sections of gravel
104	-	-	3	<10	sand
105	-	-	1.5-3	-	till
106	-	-	2-3	variable	
107	-	-	3-5	variable	mainly fine to coarse gravel with 0.3 m thick clay lens
108	-	-	3-4	<20	partially overgrown
109	-	-	<1.5	-	sand, overgrown
110	-	-	2-5	<10	fine sand
111	-	-	2-3	<10	medium sand with minor amounts of fine gravel
112	-	-	2	<5	water on floor
113	-	-	2-3	<5	water on floor
114	-	-	2	-	till
115	-	-	1.5-3	-	till
116	-	-	1-3	-	till
117	-	-	2-3	-	till, bedrock in floor

TABLE 2 - SAND AND GRAVEL PITS
VICTORIA COUNTY

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
ELDON TOWNSHIP					
Licenced Pits					
118	Bolsover Sand and Gravel Ltd.	16.20	3–8	10–15	
119	P. Imrie	7.70	3–8	10–15	
120	R.Young Const. Ltd.	14.00	5–8	40–60	sand pockets
121	J. & D. Everson	22.80	–	–	
122	J. & D. Everson	13.20	5–20	variable	highly variable material
123	K. Summers	2.70	5–6	–	sand
124	Webster Farms (Eldon) Inc.	12.20	20	50–70	
125	W.J. Spence & R. Morrison	22.70	3–18	60–80	overgrown, water in pit floor
126	Gail Helen Snodden	6.10	3–18	variable	
127	Township of Eldon	2.80	3	60–80	partially overgrown
128	County of Victoria	30.80	6–20	40–70	
129	K. A. Whitton	10.90	2–3	50–80	
Unlicenced Pits					
130	–	–	2–4	5–10	partially overgrown
131	–	–	2–3	40–60	partially overgrown
132	–	–	3–6	40–60	
133	–	–	5–6	–	sand
134	–	–	3–8	–	sand
135	–	–	1–2	–	sand
136	–	–	1–2	40–60	
137	–	–	1–2	10–25	
138	–	–	3–5	10–25	
139	–	–	5–6	35–50	
140	–	–	1–2	–	small abandoned pit
141	–	–	5–7	30–50	ice–contact deposit
142	–	–	5–7	30–50	ice–contact deposit
143	–	–	1–2	30–50	ice–contact deposit
144	–	–	1–2	30–50	ice–contact deposit
145	–	–	1	20–40	small pit in ice–contact deposit
FENELON TOWNSHIP					
Licenced Pits					
146	C.J.T. Brentnell	17.80	3–6	50–80	
147	I. L. Webster	16.00	2–4	50–60	primarily fine to coarse gravel
148	Ormell Sand and Gravel Ltd.	68.00	5–8	30–60	
149	M. Peel	14.70	3–6	60–80	
150	W.G. Jackett and Sons Construction Company	51.60	18	30–60	bedded sand and gravel

TABLE 2 - SAND AND GRAVEL PITS
VICTORIA COUNTY

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
151	Ormell Sand and Gravel Ltd.	42.1	8-30	30-60	bedded sand and gravel, water in pit floor
152	Township of Fenelon	29.1	-	-	
153	Black Bear Estates Inc. c/o J.R. Webster	32.10	3-5	40-60	fine to coarse gravel
154	Royel Paving Ltd.	68.90	-	-	
155	Royel Paving Ltd.	13.30	2-5	50-70	
156	Royel Paving Ltd.	42.20	6	50-60	
157	K. W. Estate c/o D. Worsley	28.40	3-18	40-60	bedded sand and gravel
158	Township of Fenelon	38.00	8-11	60-80	partially overgrown
159	D.R. Simser	40.50	6-9	30-50	
160	M. Fudge	6.10	3-5	25-60	
161	Royel Paving Ltd.	44.60	2-3	60-80	
Unlicenced Pits					
162	-	-	3-5	40-60	
163	-	-	3	20-40	
164	-	-	15	60-80	
165	-	-	5-8	30-50	
166	-	-	18	30-40	
167	-	-	2	30-45	ice-contact deposit
168	-	-	2	0-10	predominantly sand
169	-	-	5-6	30-50	
170	-	-	3	20-40	
VERULAM TOWNSHIP					
Licenced Pits					
171	I.L.W. Resources Inc.	19.2	2-4	40-60	overgrown, water in pit floor
172	H. W. Arscott	21.1	3-8	70-75	partially rehabilitated
173	W.B. Martin	2.8	3-4	variable	water in pit floor
174	G. Harrison	10.17	1.4	-	mainly sand
175	J.M. Jones	2.3	2-3	60-70	
176	Township of Verulam	15.4	2-4	40-60	fine to coarse gravel
177	Kawartha Dairy Ltd.	26.7	5-8	50-70	
178	M.M. O'Neill	15.7	6-8	50-70	
179	G. and A. M. Jackett	30.4	5-15	50-70	
180	County of Victoria	31.1	5-12	50-70	
181	Township of Verulam	4.2	8-11	50-70	
182	B.A. Falls	25.5	3-6	60-70	
183	M.F. & M.E. Johnson	12.2	2-4	-	
Unlicenced Pits					
184	-	-	2-5	10-20	
185	-	-	2-3	60-80	
186	-	-	3-6	40-60	overgrown
187	-	-	2-3	60-70	

TABLE 2 – SAND AND GRAVEL PITS
VICTORIA COUNTY

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
188	–	–	3–4	40–50	overgrown
189	–	–	3–5	50–70	
190	–	–	3–5	40–50	partially overgrown
191	–	–	3–5	–	sand
192	–	–	2–3	–	till
193	–	–	1–2	–	sand
194	–	–	1–2	20–30	small pit, development to the north
MARIPOSA TOWNSHIP					
Licenced Pits					
195	F.R. & D.D. Teel	40.50	15–18	10–80	variable material
196	Teel's Garage Inc. & G.E. Desjardins	9.70	3–5	60–80	
197	Bedard Sand and Gravel Limited	34.30	5–8	variable	gravel layers <1.5 m thick
198	B. Neill	8.20	3–8	30–50	
199	J.Whyte Farms Ltd.	13.00	–	variable	
200	Blue Circle Aggregates Canada Ltd.	31.10	3–8	60–80	clay and water in pit floor
201	D. McKague	19.27	–	–	
202	Township of Mariposa	11.62	–	–	
203	Royel Paving Ltd.	19.40	2–3	50–60	
204	D.B. Webster	59.90	8–9	60–80	
205	D. Zeldin	9.30	3–6	variable	gravel with sand layers
206	Township of Mariposa	16.20	2–5	30	gravel from below water table; faces overgrown
207	P.W. Tamlin	10.20	3	30–50	gravel from below water table
208	J.H. Bedard	7.30	3	–	
209	S. Tamlin	27.20	1.5–9	variable	variable material
210	R.L. Sproule	13.50	6–9	80	
211	J.H. and C.A. Bedard	10.20	3–8	30–50	
212	T.R. Brown Const. Ltd.	54.40	4–5	variable	pockets of gravel and silty fine sand
213	281965 Ontario Ltd.	6.00	6–9	–	till
214	T.H. & D.R. Forsythe	2.50	2–3	30	
Unlicenced Pits					
215	–	–	3–5	35–50	
216	–	–	1–2	40	partially rehabilitated
217	–	–	3–6	60–70	
218	–	–	2–5	–	overgrown
219	–	–	2	10–20	small pit on north side of road
220	–	–	3–5	15–35	ice-contact deposit, material variable
221	–	–	4	55	
222	–	–	2	–	partially rehabilitated
223	–	–	2–3	40–50	
224	–	–	1–2	variable	small ice-contact deposit
225	–	–	1–2	–	small ice-contact deposit

TABLE 2 - SAND AND GRAVEL PITS
VICTORIA COUNTY

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
226	-	-	1-3	-	till material
227	-	-	2-3	30	
OPS TOWNSHIP					
Licenced Pits					
228	Nelson Financial Group	28.69	2	-	
229	F.J. Deyell	7.7	3	-	
Unlicenced Pits					
230	-	-	8	-	
231	-	-	2	-	
232	-	-	6	-	
233	-	-	3-5	-	
234	-	-	8	-	
235	-	-	-	-	
236	-	-	3	-	
237	-	-	3-4	-	
238	-	-	1-2	-	predominantly sand
239	-	-	2-3	-	
240	-	-	3	-	
241	-	-	2	-	
242	-	-	2-3	-	small ice-contact deposit
243	-	-	1	-	small ice-contact deposit
EMILY TOWNSHIP					
Licenced Pits					
244	W.J. O'Neill	38.40	2	-	
245	F. Whibley	7.60	3	-	
246	L. O'Connell	17.30	6	60	interbedded sand and gravel
247	W.R. Mahood	40.90	8	55	
248	D.E. O'Neill	5.80	4-15	variable	interbedded sand and gravel
249	D.E. O'Neill	20.20	-	60	
250	R. Young Const. Ltd.	57.90	9	60-80	
251	D. McQuaid	20.70	8	75	
252	Lloyd A. Banks	33.30	-	-	
253	K.E. Mitchell	20.30	8	55	
254	C.W. Spence	3.00	2-3	65	slumped, overgrown
255	Township of Emily	46.00	4-25	variable	primarily sand
256	K.G. O'Neill	6.10	8	20	
257	D.T. Doughty	28.00	2-30	variable	
258	Doughty Aggregates (Peterborough) Ltd.	4.30	6	0-80	
259	L.R. Sholer	7.90	6	<35	
260	B.T. & V.J. Callan	36.50	6	50	
261	Don James & Sons, Sand & Gravel Limited	5.90	8	65	
262	K.L.W. Doughty	20.90	5-20	variable	interbedded sand and gravel

TABLE 2 - SAND AND GRAVEL PITS
VICTORIA COUNTY

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
Unlicenced Pits					
263	-	-	2-4	variable	pit developed along esker ridge
264	-	-	3-6	50	
265	-	-	5	-	
266	-	-	5	45-50	
267	-	-	7-9	-	rehabilitated
268	-	-	2-4	variable	pit developed along esker ridge
269	-	-	1-1.5	variable	abandoned pit in outwash deposit
270	-	-	2-7	-	partially overgrown
271	-	-	3-9	-	partially overgrown
272	-	-	-	-	
273	-	-	2-3	-	
274	-	-	5	-	
275	-	-	-	-	
276	-	-	3	-	
277	-	-	3	-	
278	-	-	9-12	-	
279	-	-	2	-	
280	-	-	4	-	
281	-	-	3-4	-	
282	-	-	9	45	rehabilitated
283	-	-	9	40-50	
284	-	-	5-6	-	
285	-	-	3	-	
286	-	-	3-8	-	bottom 3 m are sandy, 35% stone
287	-	-	2-3	-	small, badly overgrown pit
288	-	-	2-4	-	predominantly fine to medium sand
MANVERS TOWNSHIP					
Licenced Pits					
289	J.R. Vivian	34.40	11	-	
290	St. Lawrence Cement	192.80	3	-	
291	Township of Manvers	40.10	5	-	
292	North York Sand and Gravel Limited	77.80	9	-	
293	W. Richardson	33.20	6	-	
294	B. & J. Mountjoy	40.50	4	-	
295	TRT Properties Inc.	202.40	-	-	
296	TRT Properties Inc.	415.20	6	-	
297	TRT Properties Inc.	11.80	6	-	
298	1266558 Ontario Inc.	63.00	6	-	
299	Bennett Paving & Materials Limited	41.20	18	-	
300	TRT Aggregates Ltd.	42.90	-	-	
301	1266553 Ontario Inc.	40.50	3-5	-	
302	C.D.R. Young's Aggregates Inc.	23.80	5	-	

TABLE 2 - SAND AND GRAVEL PITS
VICTORIA COUNTY

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
303	Van Drunen & Sons Gravel Limited	8.10	6-9	-	
304	612118 Ontario Limited	77.8	3	-	
305	M.W. Kirk & K.O. Loshaw	22.7	6	-	
Unlicenced Pits					
306	-	-	3	-	
307	-	-	2	-	
308	-	-	11	-	
309	-	-	2-3	-	predominantly sand
310	-	-	2-3	-	predominantly sand
311	-	-	2-3	-	predominantly sand
312	-	-	2-3	-	
313	-	-	12	-	
314	-	-	3	-	
315	-	-	3	-	
316	-	-	3	-	
317	-	-	9	-	
318	-	-	9-15	-	
319	-	-	4-6	-	rehabilitated
320	-	-	3-6	-	
321	-	-	4-6	-	rehabilitated
322	-	-	2-5	-	sand
323	-	-	1-2	-	predominantly sand
324	-	-	3	-	
325	-	-	6	-	
326	-	-	3-4	-	predominantly sand
327	-	-	3	-	
328	-	-	3	-	
329	-	-	2	-	
330	-	-	6	-	
331	-	-	3	-	
332	-	-	-	-	
333	-	-	1	-	
334	-	-	3	-	
335	-	-	5	-	
336	-	-	2	-	
337	-	-	4	-	
338	-	-	6-11	-	
339	-	-	2	-	

* This property is licensed for both pit and quarry operations.

TABLE 3 – SELECTED SAND AND GRAVEL RESOURCE AREAS VICTORIA COUNTY

1 Deposit No.	2 Unlicenced Area (Hectares)*	3 Cultural Setback (Hectares)**	4 Extracted Area (Hectares)***	5 Possible Resource Area (Hectares)	6 Estimated Deposit Thickness (Metres)	7 Possible Aggregate Resources**** (Million Tonnes)
1a	30	7	1	22	4.5	1.8
1b	27	0	1	26	4.5	2.1
1c	46	11	1	34	4.5	2.7
1d	6	0	1	5	6.0	0.5
1e	3	0	0	3	6.0	0.3
1f	137	32	1	104	4.5	8.3
2a	24	3	1	20	4.0	1.4
2b	14	5	0	9	4.0	0.6
3a	145	61	5	79	5.5	7.7
3b	59	21	0	38	4.0	2.7
3c	73	17	5	51	4.0	3.6
4a	51	0	2	49	4.0	3.5
4b	77	2	0	75	2.5	3.3
5	98	1	1	96	5.0	8.5
6	77	10	2	65	6.0	6.9
7	37	3	3	31	5.0	2.7
8	300	42	4	254	5.0	22.5
9	116	10	2	104	6.0	11.0
10	202	27	0	175	11.0	34.1
11a	84	6	2	76	6.0	8.1
11b	305	44	2	259	5.0	22.9
12	78	11	3	64	6.0	6.8
13	769	73	4	692	7.0	85.7
14	273	35	3	235	5.0	20.8
15	215	137	2	76	5.0	6.7
16a	17	5	1	11	5.0	1.0
16b	190	41	5	144	5.0	12.7
17	9	1	0	8	6.0	0.9

TABLE 3 - SELECTED SAND AND GRAVEL RESOURCE AREAS
VICTORIA COUNTY

1 Deposit No.	2 Unlicenced Area (Hectares)*	3 Cultural Setback (Hectares)**	4 Extracted Area (Hectares)***	5 Possible Resource Area (Hectares)	6 Estimated Deposit Thickness (Metres)	7 Possible Aggregate Resources**** (Million Tonnes)
18	126	40	23	63	6.0	6.7
19	275	53	20	202	7.0	25.0
20	435	150	2	283	8.0	40.1
21	1040	260	4	776	6.0	82.4
22	231	37	2	192	5.0	17.0
23	88	10	10	68	8.0	9.6
24	1820	390	8	1422	11.0	276.9
Victoria County Total						
	7477	**1545**	**121**	**5811**		**747.5**

Minor variations in all tables are caused by the rounding of data

* Excludes areas licenced under the Aggregate Resources Act (1989).

** Cultural setbacks include heavily populated urban areas, roads (including a 100 m wide strip centred on each road), water features (e.g., lakes, streams), 1 ha for individual houses. NOTE: this provides a preliminary and generalized constraint application only. Additional envi. mental and social constraints will further reduce the deposit area.

*** Extracted area is a rough estimate of areas that are not licenced but largely depleted such as abandoned and wayside pit sites.

**** Further environmental, resource, social and economic constraints will greatly reduce the selected resource quantity realistically available for potential extraction.

TABLE 4 – TOTAL IDENTIFIED BEDROCK RESOURCES
VICTORIA COUNTY

1 Drift Thickness (Metres)	2 Formation	3 Estimated Deposit Thickness (Metres)	4 Areal Extent (Hectares)	5 Original Tonnage (Million Tonnes)
LONGFORD TOWNSHIP				
		None		
DALTON TOWNSHIP				
<1	Bobcaygeon	18	151	72
1 to 8	Bobcaygeon	18	<1	<1
<1	Gull River	18	395	188
1 to 8	Gull River	18	23	11
<1	Shadow Lake	3	117	9
1 to 8	Shadow Lake	3	186	15
Subtotal			**872**	**295**
DIGBY TOWNSHIP				
<1	Bobcaygeon	18	32	15
<1	Gull River	18	840	401
1 to 8	Gull River	18	620	296
<1	Shadow Lake	3	67	5
1 to 8	Shadow Lake	3	330	26
Subtotal			**1889**	**743**
LAXTON TOWNSHIP				
<1	Bobcaygeon	18	4400	2098
1 to 8	Bobcaygeon	18	360	172
8 to 15	Bobcaygeon	18	12	6
<1	Gull River	18	2110	1006
1 to 8	Gull River	18	950	453
<1	Shadow Lake	3	116	9
1 to 8	Shadow Lake	3	199	16
Subtotal			**8147**	**3760**
CARDEN TOWNSHIP				
<1	Verulam	2	415	22
1 to 8	Verulam	2	295	16
<1	Bobcaygeon	18	8900	4244
1 to 8	Bobcaygeon	18	6100	2909
8 to 15	Bobcaygeon	18	104	50
<1	Gull River	18	315	150
1 to 8	Gull River	18	1520	725
8 to 15	Gull River	18	89	42

TABLE 4 – TOTAL IDENTIFIED BEDROCK RESOURCES VICTORIA COUNTY				
1 Drift Thickness (Metres)	2 Formation	3 Estimated Deposit Thickness (Metres)	4 Areal Extent (Hectares)	5 Original Tonnage (Million Tonnes)
<1	Shadow Lake	3	38	3
1 to 8	Shadow Lake	3	260	21
8 to 15	Shadow Lake	3	5	<1
Subtotal			**18041**	**8182**
BEXLEY TOWNSHIP				
<1	Verulam	18	4	2
1 to 8	Verulam	18	74	35
8 to 15	Verulam	18	15	7
<1	Bobcaygeon	18	2040	973
1 to 8	Bobcaygeon	18	8600	4101
8 to 15	Bobcaygeon	18	125	60
<1	Gull River	18	118	56
1 to 8	Gull River	18	1070	510
8 to 15	Gull River	18	106	51
1 to 8	Shadow Lake	3	6	<1
Subtotal			**12158**	**5795**
SOMERVILLE TOWNSHIP				
<1	Bobcaygeon	18	2800	1335
1 to 8	Bobcaygeon	18	9000	4291
8 to 15	Bobcaygeon	18	66	31
<1	Gull River	18	226	108
1 to 8	Gull River	18	3000	1430
8 to 15	Gull River	18	285	136
<1	Shadow Lake	3	33	3
1 to 8	Shadow Lake	3	425	34
8 to 15	Shadow Lake	3	27	2
Subtotal			**15862**	**7370**
ELDON TOWNSHIP				
<1	Lindsay	18	213	102
1 to 8	Lindsay	18	9900	4721
8 to 15	Lindsay	18	1250	596
<1	Verulam	18	2080	992
1 to 8	Verulam	18	10500	5007
8 to 15	Verulam	18	640	305
<1	Bobcaygeon	18	255	122

TABLE 4 – TOTAL IDENTIFIED BEDROCK RESOURCES VICTORIA COUNTY				
1 Drift Thickness (Metres)	**2 Formation**	**3 Estimated Deposit Thickness (Metres)**	**4 Areal Extent (Hectares)**	**5 Original Tonnage (Million Tonnes)**
1 to 8	Bobcaygeon	18	500	238
8 to 15	Bobcaygeon	18	91	43
Subtotal			**25429**	**12126**
FENELON TOWNSHIP				
<1	Lindsay	18	47	22
1 to 8	Lindsay	18	3250	1550
8 to 15	Lindsay	18	370	176
<1	Verulam	18	107	51
1 to 8	Verulam	18	16000	7629
8 to 15	Verulam	18	650	310
<1	Bobcaygeon	18	97	46
1 to 8	Bobcaygeon	18	1820	868
8 to 15	Bobcaygeon	18	80	38
Subtotal			**22421**	**10690**
VERULAM TOWNSHIP				
<1	Verulam	18	10	5
1 to 8	Verulam	18	18200	8678
8 to 15	Verulam	18	1670	796
<1	Bobcaygeon	18	211	101
1 to 8	Bobcaygeon	18	4600	2193
8 to 15	Bobcaygeon	18	242	115
<1	Gull River	18	14	7
1 to 8	Gull River	18	27	13
Subtotal			**24974**	**11908**
MARIPOSA TOWNSHIP				
1 to 8	Lindsay	18	14000	6775
8 to 15	Lindsay	18	3650	1740
Subtotal			**17650**	**8515**
OPS TOWNSHIP				
1 to 8	Lindsay	18	7800	3719
8 to 15	Lindsay	18	12300	5865
1 to 8	Verulam	18	490	234
Subtotal			**20590**	**9818**
EMILY TOWNSHIP				
1 to 8	Lindsay	18	3900	1860
8 to 15	Lindsay	18	4700	2241

TABLE 4 - TOTAL IDENTIFIED BEDROCK RESOURCES
VICTORIA COUNTY

1 Drift Thickness (Metres)	2 Formation	3 Estimated Deposit Thickness (Metres)	4 Areal Extent (Hectares)	5 Original Tonnage (Million Tonnes)
1 to 8	Verulam	18	5600	2670
8 to 15	Verulam	18	1860	887
Subtotal			**16060**	**7658**
MANVERS TOWNSHIP				
8 to 15	Lindsay	18	345	165
Subtotal			**345**	**165**
VICTORIA COUNTY TOTAL				
			184438	**87025**

Minor variations in all tables are caused by the rounding of d

The above figures represent a comprehensive inventory of all bedrock resources in the map area. Some of the material included in the estimate has no potential and some is unavailable for extraction due to land use restrictions.

TABLE 5 - QUARRIES
VICTORIA COUNTY

Quarry No.	Owner/Operator	Licenced Area (Hectares)	Face Height (Metres)	Remarks
LONGFORD TOWNSHIP				
			None	
DALTON TOWNSHIP				
			None	
DIGBY TOWNSHIP				
			None	
LAXTON TOWNSHIP				
Licenced Quarries				
1	J. Kay	67.33	<1.5	Flagstone quarry - thin to medium-bedded limestone
2	I.Wessel and Sons*	17.80	4.6 to 6	Precambrian gneiss
3	I.Wessel and Sons*	15.97	-	Precambrian gneiss
4	Central Ontario Natural Stone Company Ltd.	16.12	<0.3	Flagstone quarry - thin to medium-bedded limestone
5	J. Chynoweth	9.80	3 to 3.7	Medium-bedded limestone - Gull River Formation
Unlicenced Quarries				
6	-	-	<0.9	Thin to medium-bedded Gull River Formation limestone, abandoned flagstone quarry
CARDEN TOWNSHIP				
Licenced Quarries				
7	Miller Paving Limited	332.10	7	Thin to thick-bedded limestone - Bobcaygeon Formation
8	St. Lawrence Cement Inc.	218.40	14	3 m of Verulam Formation over Bobcaygeon Formation, thin to medium-bedded limestone
9	K.J. Beamish Construction Ltd.	89.60	-	
10	Warren Paving and Materials Group Ltd.	27.97	18 to 24	Thin to thick-bedded limestone - Bobcaygeon Formation
BEXLEY TOWNSHIP				
Licenced Quarries				
11	Five W Farms Inc.*	138.20	-	
Unlicenced Quarries				
12	-	-	3	Bobcaygeon Formation
SOMERVILLE TOWNSHIP				
Licenced Quarries				
13	Cedarhurst Quarries and Crushing Ltd.	41.70	5 to 6	Limestone - water on quarry floor
14	R.E. Mason	13.60	9 to 12	Limestone
15	Burnt River Quarries Inc.	104.68	8 to 9	Limestone - crushed stone and flagstone
16	I.Wessell and Sons Ltd.	29.66	-	-

TABLE 5 - QUARRIES
VICTORIA COUNTY

Quarry No.	Owner/Operator	Licenced Area (Hectares)	Face Height (Metres)	Remarks
Unlicenced Quarries				
17	-	-	4 to 5	Limestone - inactive
18	-	-	5 to 6	Limestone - water on quarry floor
19	-	-	1.5 to 3	Limestone - overgrown
20	-	-	1.5 to 3	Limestone - partially overgrown
ELDON TOWNSHIP				
Unlicenced Quarries				
21	-	-	11	Approximately 3 m of Verulam Formation over Bobcaygeon Formation
FENELON TOWNSHIP				
			None	
VERULAM TOWNSHIP				
Unlicenced Quarries				
22	-	-	6	Bobcaygeon Formation
MARIPOSA TOWNSHIP				
Unlicenced Quarries				
23	-	-	3	Lindsay Formation
OPS TOWNSHIP				
			None	
EMILY TOWNSHIP				
			None	
MANVERS TOWNSHIP				
			None	

* These properties are licenced for pit and quarry operations.

TABLE 6 - SELECTED BEDROCK RESOURCES
VICTORIA COUNTY

1 Area No.	2 Depth of Overburden (Metres)	3 Area (Hectares)*	4 Cultural Setbacks (Hectares)**	5 Extracted Area (Hectares)***	6 Possible Resource Area (Hectares)	7 Estimated Workable Thickness (Metres)	8 Possible Bedrock Resources**** (Million Tonnes)
LONGFORD TOWNSHIP							
				None			
DALTON TOWNSHIP							
1	0 to 1	290	30	0	260	18	124
	1 to 8	7	4	0	3	18	1
2	0 to 1	151	0	0	151	18	72
	1 to 8	<1	0	0	<1	18	<1
Subtotal		**448**	**34**	**0**	**414**		**197**
DIGBY TOWNSHIP							
1	0 to 1	720	114	0	606	18	289
	1 to 8	570	42	0	528	18	252
2	0 to 1	32	0	0	32	18	15
Subtotal		**1322**	**156**	**0**	**1166**		**556**
LAXTON TOWNSHIP							
1	0 to 1	2080	310	1	1769	18	844
	1 to 8	950	179	0	771	18	368
2	0 to 1	4350	350	0	4000	18	1907
	1 to 8	360	100	0	260	18	124
Subtotal		**7740**	**939**	**1**	**6800**		**3243**
CARDEN TOWNSHIP							
1	0 to 1	315	13	0	302	18	144
	1 to 8	1520	250	0	1270	18	606
2	0 to 1	8700	360	0	8340	18	3977
		5900	790	0	5110	18	2437
Subtotal		**16435**	**1413**	**0**	**15022**		**7164**
BEXLEY TOWNSHIP							
1	0 to 1	118	10	0	108	18	51
	1 to 8	1070	187	0	883	18	421
2	0 to 1	2040	335	0	1705	18	813
	1 to 8	8200	1160	1	7039	18	3357
Subtotal		**11428**	**1692**	**1**	**9735**		**4642**

TABLE 6 – SELECTED BEDROCK RESOURCES
VICTORIA COUNTY

1 Area No.	2 Depth of Overburden (Metres)	3 Area (Hectares)*	4 Cultural Setbacks (Hectares)**	5 Extracted Area (Hectares)***	6 Possible Resource Area (Hectares)	7 Estimated Workable Thickness (Metres)	8 Possible Bedrock Resources**** (Million Tonnes)
SOMERVILLE TOWNSHIP							
1	0 to 1	222	17	0	205	18	98
	1 to 8	3000	570	3	2427	18	1157
2	0 to 1	2800	212	0	2588	18	1234
	1 to 8	8900	1160	1	7739	18	3690
Subtotal		**14922**	**1959**	**4**	**12959**		**6179**
ELDON TOWNSHIP							
2	0 to 1	190	58	1	131	18	62
	1 to 8	500	163	0	337	18	161
Subtotal		**690**	**221**	**1**	**468**		**223**
FENELON TOWNSHIP							
2	0 to 1	74	24	0	50	18	24
	1 to 8	1520	610	0	910	18	434
Subtotal		**1594**	**634**	**0**	**960**		**458**
VERULAM TOWNSHIP							
2	0 to 1	112	48	0	64	18	31
	1 to 8	4100	940	1	3159	18	1506
Subtotal		**4212**	**988**	**1**	**3223**		**1537**
MARIPOSA TOWNSHIP				**None**			
OPS TOWNSHIP				**None**			
EMILY TOWNSHIP				**None**			
MANVERS TOWNSHIP				**None**			
VICTORIA COUNTY – TOTAL FOR AREA 1							
		10862	**1726**	**4**	**9132**		**4355**
VICTORIA COUNTY – TOTAL FOR AREA 2							
		47929	**6310**	**4**	**41615**		**19844**

TABLE 6 - SELECTED BEDROCK RESOURCES
VICTORIA COUNTY

1 Area No.	2 Depth of Overburden (Metres)	3 Area (Hectares)*	4 Cultural Setbacks (Hectares)**	5 Extracted Area (Hectares)***	6 Possible Resource Area (Hectares)	7 Estimated Workable Thickness (Metres)	8 Possible Bedrock Resources**** (Million Tonnes)
VICTORIA COUNTY - GRAND TOTAL (AREA 1 AND 2)							
		58791	**8036**	**8**	**50747**		**24199**

Minor variations in all tables are caused by the rounding of data.

* Excludes areas licenced under the Aggregate Resources Act (1989).

** Cultural setbacks include heavily populated urban areas, roads (including a 100 m wide strip centred on each road), water features (e.g., lakes, streams), 1 ha for individual houses. NOTE: this provides a preliminary and generalized constraint application only. Additional environmental and social constraints will further reduce the bedrock resource area.

*** Extracted area is a rough estimate of areas that are not licenced but largely depleted such as abandoned quarry sites.

**** Further environmental, resource, social and economic constraints will greatly reduce the selected resource quantity realistically available for potential extraction.

TABLE 7 - SUMMARY OF TEST HOLE DATA VICTORIA COUNTY
NONE

TABLE 8 - SUMMARY OF GEOPHYSICAL DATA VICTORIA COUNTY
NONE

TABLE 9 - RESULTS OF AGGREGATE QUALITY TESTS
VICTORIA COUNTY

	COARSE AGGREGATE					FINE AGGREGATE
	Petrographic Number					
Sample No.	Granular & 16 mm crushed	Hot Mix & Concrete	Magnesium Sulphate Soundness (% Loss)	Absorption (%)	Los Angeles Abrasion (% Loss)	Micro Deval Abrasion (% Loss)
Pit No. 4	124	193	10.0	0.900	-	24.0
Pit No. 15	120	152	7.0	0.600	-	16.0
Pit No. 22	123	156	6.0	0.630	-	16.0
Pit No. 40	122	167	12.0	0.800	-	20.0
Pit No. 33	142	186	11.0	0.920	-	23.0
Pit No. 68	142	160	22.7	1.190	-	18.6
Pit No. 70a	123	185	18.8	1.210	-	9.0
Pit No. 70b	-	-	-	-	-	6.3
Pit No. 103	112	123	16.0	0.810	-	21.0
Pit No. 147	119	124	21.6	0.740	-	14.2
Pit No. 172	110	119	15.8	0.750	23	18.4
Pit No. 176	115	126	-	0.870	26	15.0
Pit No. 209	114	121	-	0.620	24	12.8
Pit No. 247	124	131	18.3	0.810	-	18.9
Pit No. 321	104	109	16.2	-	-	13.2
Quarry 18	100	113	5.0	0.570	-	14.0
VC-SS-1	135	161	-	0.940	-	15.3

NOTE: The quality test data refers strictly to a specific sample. Because of the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

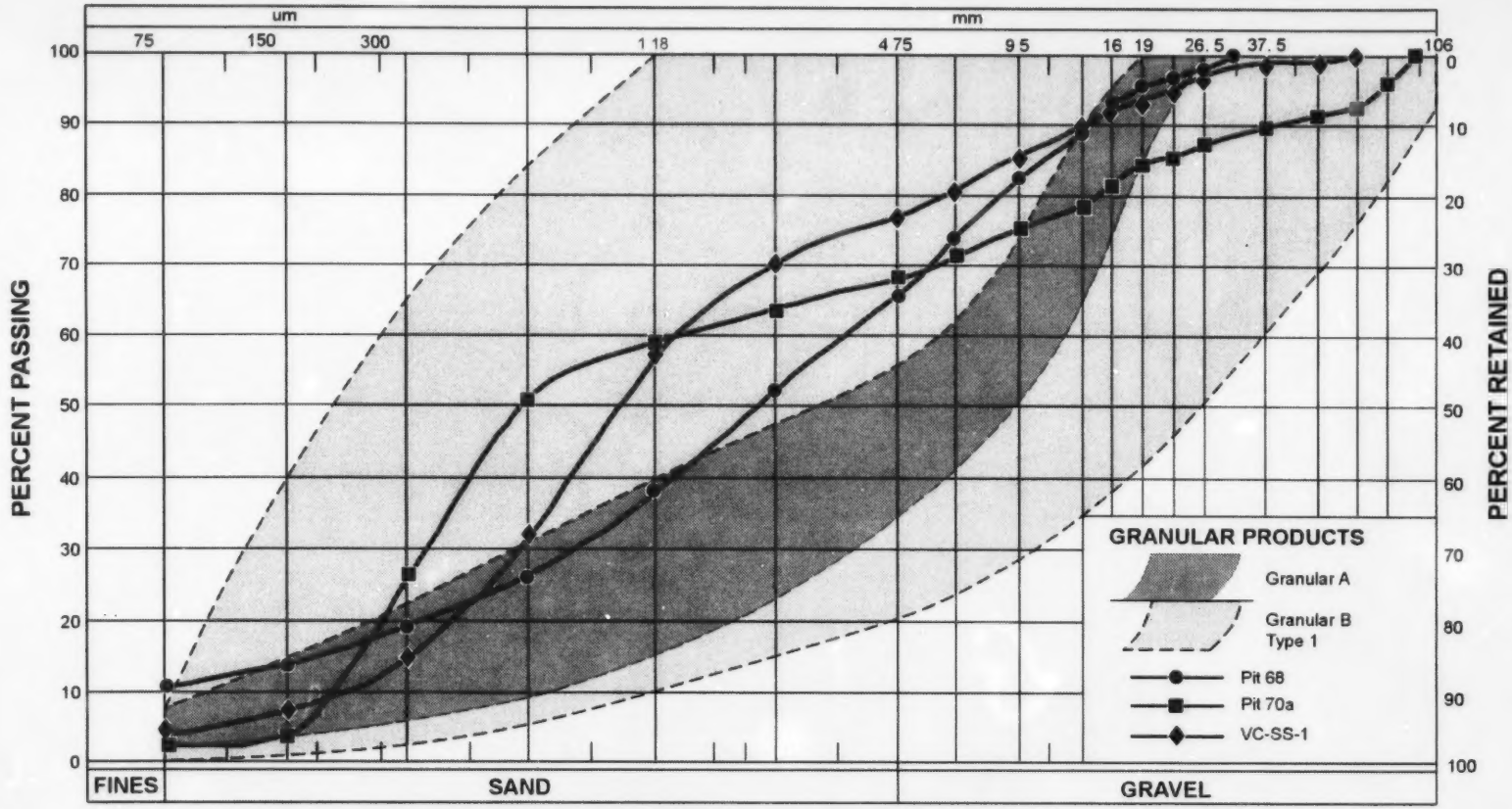


FIGURE 3A AGGREGATE GRADING CURVES, VICTORIA COUNTY

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from Ontario Provincial Standard Specifications OPSS 1010, 1988).

NOTE:
Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

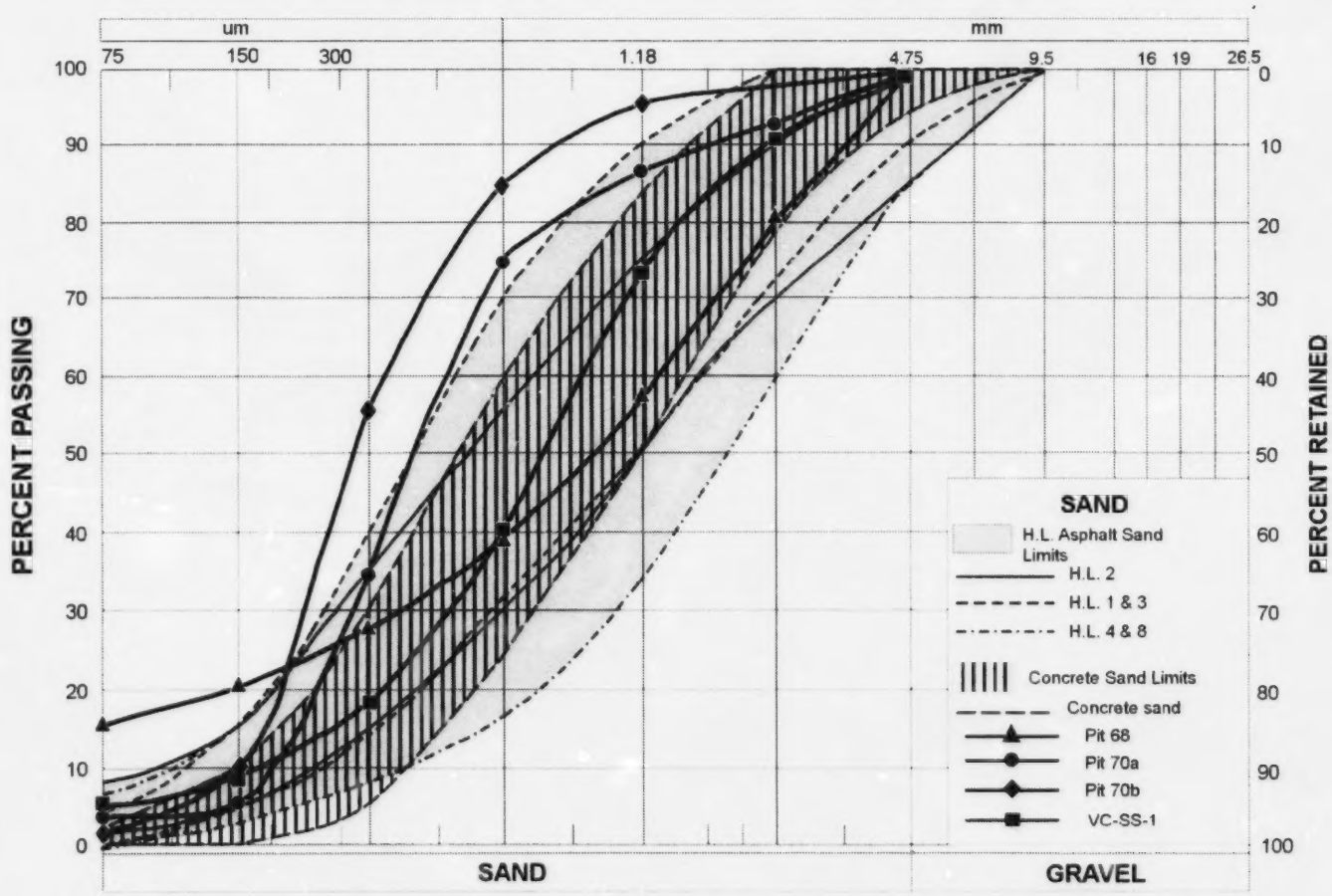


FIGURE 3B AGGREGATE GRADING CURVES,VICTORIA COUNTY

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from Ontario Provincial Standard Specifications OPSS 1002, 1988 and 1003, 1988).

NOTE:
Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

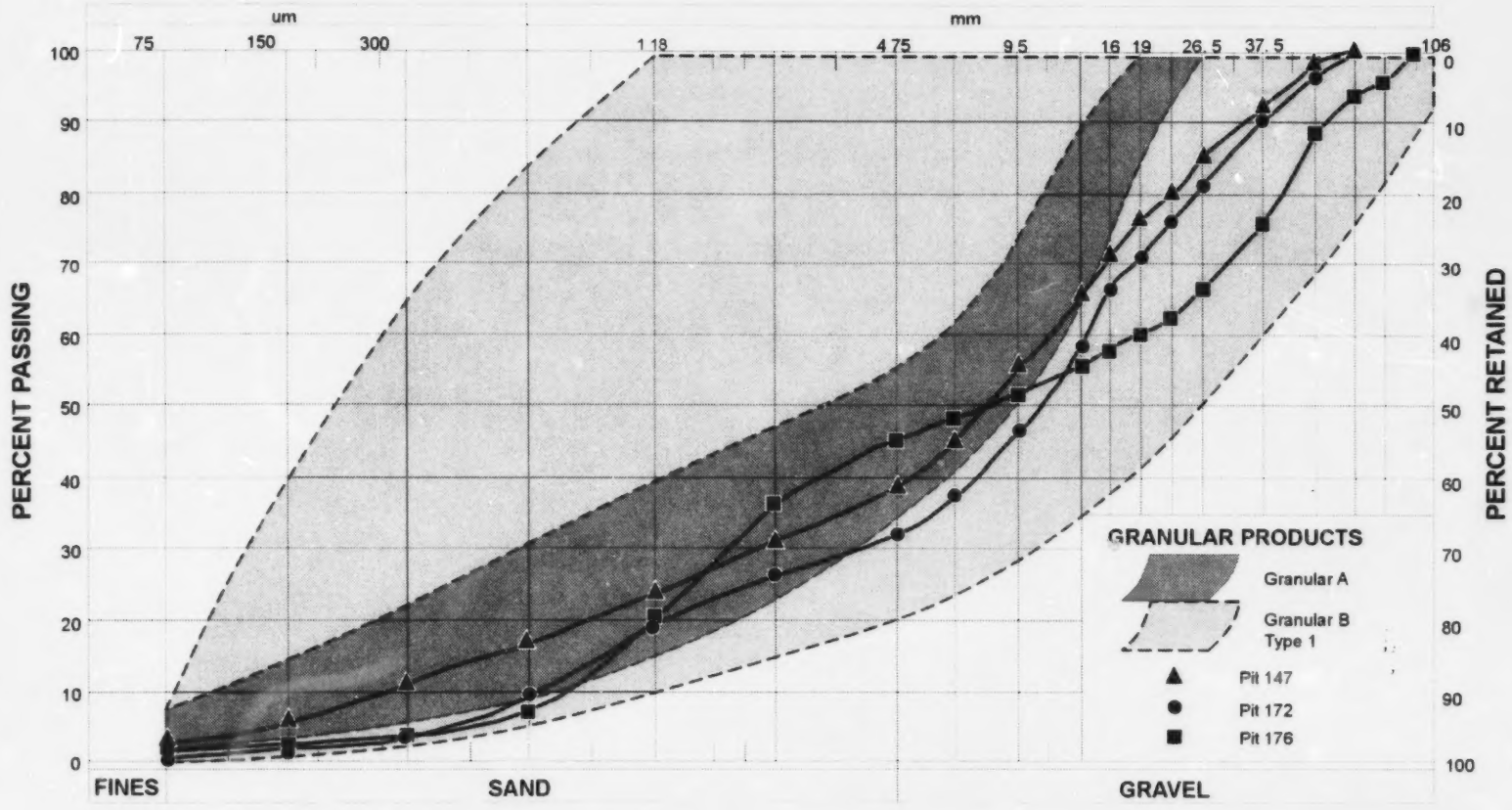


FIGURE 4A AGGREGATE GRADING CURVES, VICTORIA COUNTY

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from Ontario Provincial Standard Specifications OPSS 1010, 1988).

NOTE:
Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

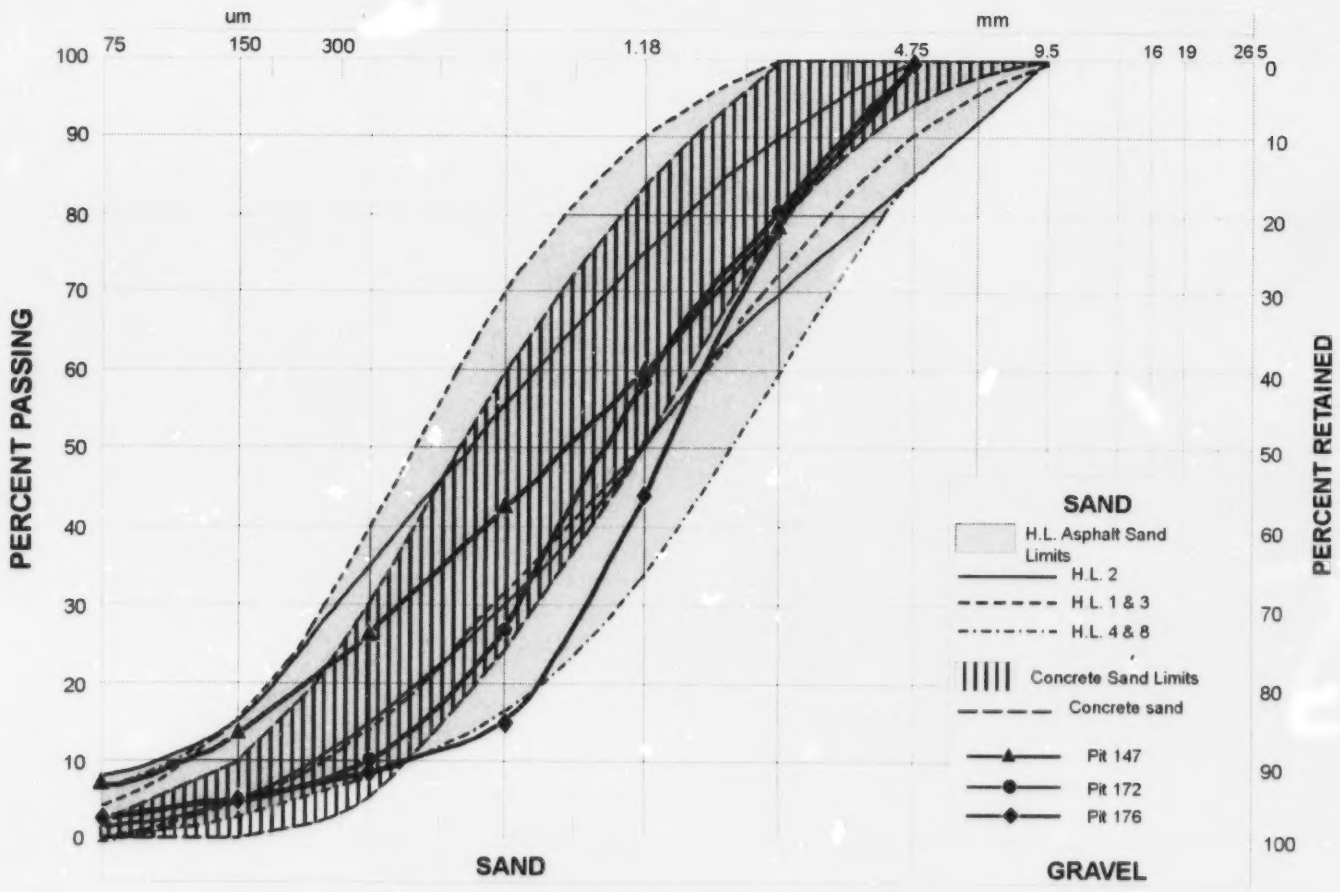


FIGURE 4B AGGREGATE GRADING CURVES,VICTORIA COUNTY

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from Ontario Provincial Standard Specifications OPSS 1002, 1988 and 1003, 1988).

NOTE:
Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

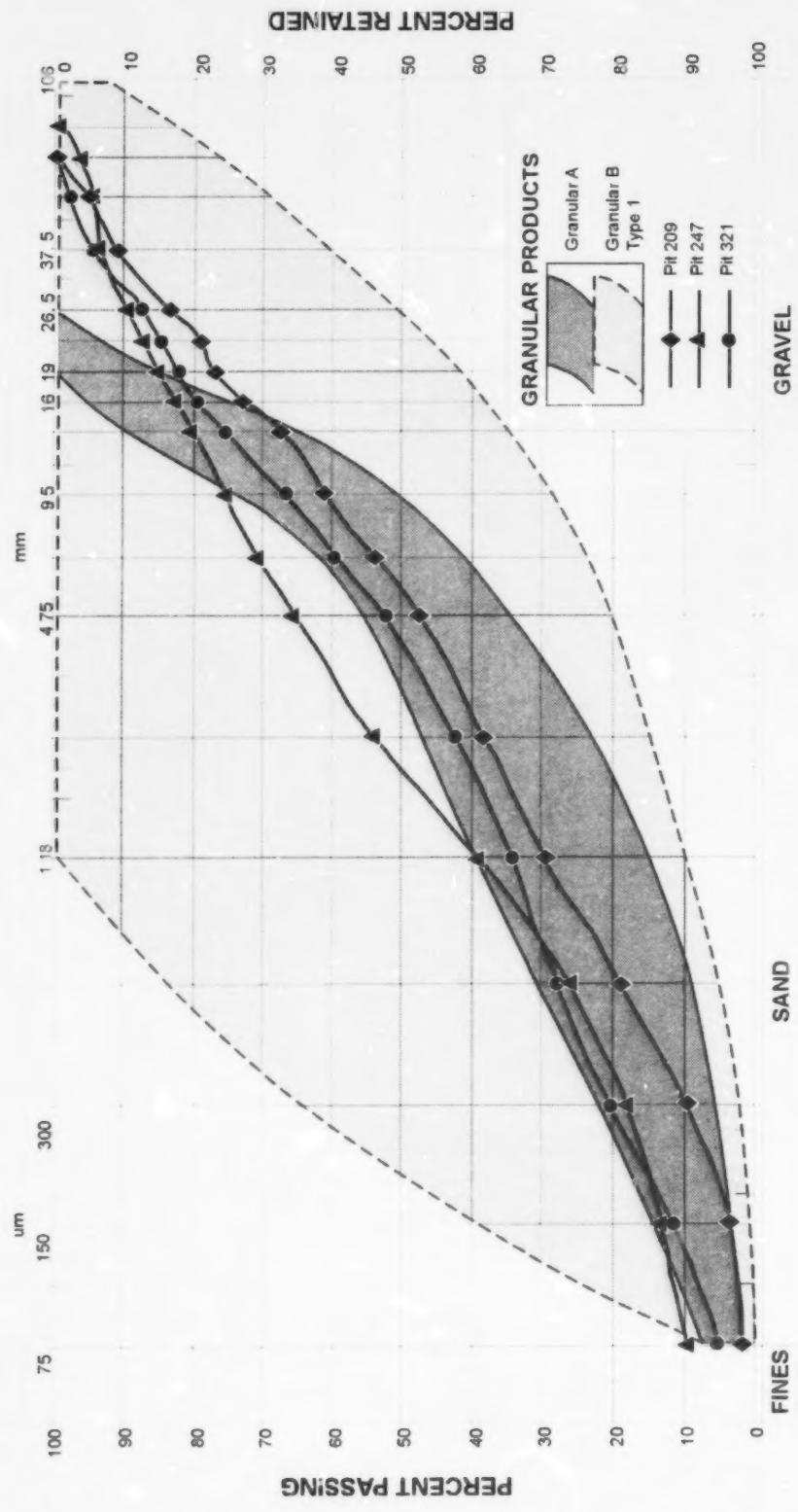


FIGURE 5A AGGREGATE GRADING CURVES, VICTORIA COUNTY

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from Ontario Provincial Standard Specifications OPSS 1010, 1988).

NOTE:
Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

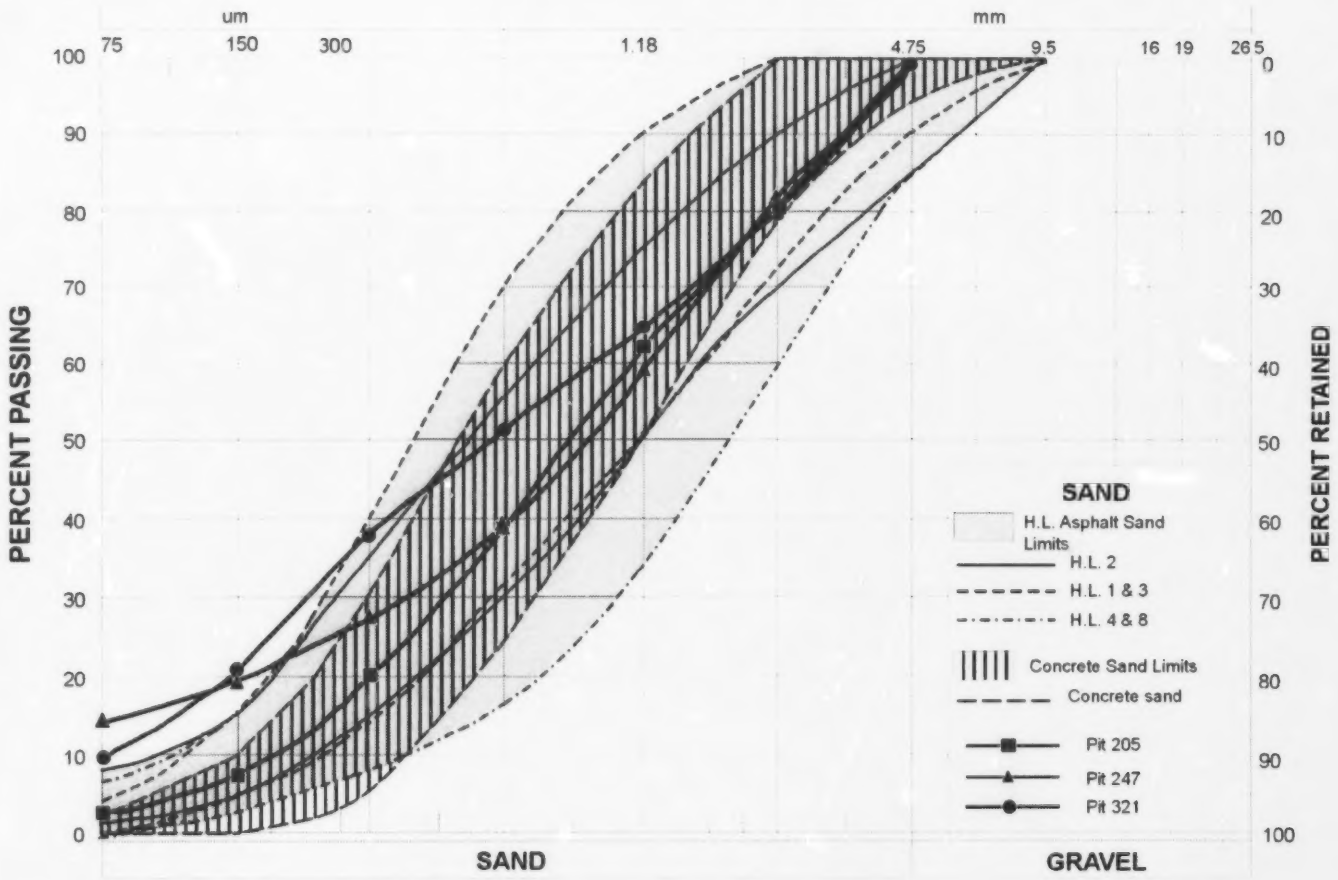


FIGURE 5B AGGREGATE GRADING CURVES,VICTORIA COUNTY

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from Ontario Provincial Standard Specifications OPSS 1002, 1988 and 1003, 1988).

NOTE:
Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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Appendix B – Glossary

Abrasion resistance: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

Absorption capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

Acid-Soluble Chloride Ion Content: This test measures total chloride ion content in concrete and is used to judge the likelihood of re-bar corrosion and susceptibility to deterioration by freeze-thaw in concrete structures. There is a strong positive correlation between chloride ion content and depassivation of reinforcing steel in concrete. Depassivation permits corrosion of the steel in the presence of oxygen and moisture. Chloride ions are contributed mainly by the application of de-icing salts.

Aggregate: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

Aggregate Abrasion Value: This test directly measures the resistance of aggregate to abrasion with silica sand and a steel disk. The higher the value, the lower the resistance to abrasion. For high quality asphalt surface course uses, values of less than 6 are desirable.

Alkali-aggregate reaction: A chemical reaction between the alkalies of Portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

Beneficiation: Beneficiation of aggregates is a process or combination of processes which improves the quality (physical properties) of a mineral aggregate and is not part of the normal processing for a particular use, such as routine crushing, screening, washing, or classification. Heavy media separation, jigging, or application of special crushers (e.g., "cage mill") are usually considered processes of beneficiation.

Blending: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

Bulk Relative Density: The density of a material related to water at 4°C and atmospheric pressure at sea level. An aggregate with low relative density is lighter in weight than one with a high relative density. Low relative density aggregates (less than about 2.5) are often non-durable for many aggregate uses.

Cambrian: The first period of the Paleozoic Era, thought to have covered the time between 570 and 505 million years age. The Cambrian precedes the Ordovician Period.

Chert: Amorphous silica, generally associated with limestone. Often occur as irregular masses or lenses but can also occur finally disseminated through limestones. It may be very hard in unleached form. In leached form, it is white and "chalky" and is very absorptive. It has deleterious effect for aggregates to be used in Portland cement concrete due to reactivity with alkalies in Portland cement.

Clast: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

Crushable Aggregate: Unprocessed gravel containing a minimum of 35% coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20% greater than the 26.5 mm sieve.

Deleterious lithology: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

Devonian: A period of the Paleozoic Era thought to have covered the span of time between 408 and 360 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest Paleozoic rocks in Ontario.

Dolostone: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

Drift: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

Drumlin: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

Eolian: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

Fines: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

Glacial lobe: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in Ontario.

Gneiss: A coarse-textured metamorphic rock with the minerals arranged in parallel streaks or bands. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

Gradation: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

Granite: A coarse-grained, light-coloured rock that ordinarily has an even texture and is composed of quartz and feldspar with either mica, hornblende or both.

Granular Base and Subbase: Components of a pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Four types have been defined: Granular A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular B which is usually pit-run or other unprocessed aggregate; Granular M is a shouldering and surface dressing material with quality requirements similar to Granular A; Select Subgrade Material has similar quality requirements to Granular B and it provides a stable platform for the overlying pavement structure. (For more specific information the reader is referred to Ontario Provincial Standard Specification OPSS 1010).

Heavy Duty Binder: Second layer from the top of hot mix asphalt pavements, used on heavily travelled (especially by trucks) expressways, such as Highway 401. Coarse and fine aggregates are to be produced from high quality bedrock quarries, except when gravel is permitted by special provisions.

Hot-laid (or Asphaltic) Paving Aggregate: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (HL 1, 3 and 4), or as binder course (HL 2, 4 and 8) used to bind the surface course to the underlying granular base.

Limestone: A carbonate sedimentary rock consisting chiefly of the mineral calcite. It may contain the mineral dolomite up to about 40%.

Lithology: The description of rocks on the basis of such characteristics as colour, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

Los Angeles Abrasion and Impact Test: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported and placed. Values less than about 35% indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45% indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

Magnesium Sulphate Soundness Test: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible to freezing and thawing will usually break down and give high losses in this test. Values greater than about 12 to 15% indicate potential problems for concrete and asphalt coarse aggregate.

Medium Duty Binder: Second layer from the top of hot mix asphalt pavements used on heavily travelled, usually four lane highways and municipal arterial roads. It may be constructed with high quality quarried rock or high quality gravel with a high percentage of fractured faces or polymer modified asphalt cements.

Meltwater Channel: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

Ordovician: An early period of the Paleozoic Era thought to have covered the span of time between 505 and 438 million years ago.

Paleozoic Era: One of the major divisions of the geologic time scale thought to have covered the time period between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

Petrographic Examination: An aggregate quality test based on known field performance of various rock types. In Ontario the test result is a Petrographic Number (PN). The higher the PN, the lower the quality of the aggregate.

Pleistocene: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

Polished Stone Value: This test measures the frictional properties of aggregates after 6 hours of abrasion and polishing with an emery abrasive. The higher the PSV, the higher the frictional properties of the aggregate. Values less than 45 indicate marginal frictional properties, while values greater than 55 indicate excellent frictional properties.

Possible Resource: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications, but do not take into account many site-specific natural and environmental constraints that could render the resource unaccessible.

Precambrian: The earliest geological period extending from the consolidation of the earth's crust to the beginning of the Cambrian Period.

Sandstone: A clastic sedimentary rock consisting chiefly of sand-sized particles of quartz and minor feldspar, cemented together by calcareous minerals (calcite or dolomite) or by silica.

Shale: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well-developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

Siltstone: A clastic sedimentary rock consisting chiefly of silt-sized particles, cemented together by calcareous minerals (calcite and dolomite) or by silica.

Silurian: An early period of the Paleozoic era thought to have covered the time between 438 and 408 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

Soundness: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

Till: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

Wisconsinan: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C – Geology of Sand and Gravel Deposits

The type, distribution and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers, consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well-developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Subaqueous Fans (SF): Subaqueous fans are formed within or near the mouths of meltwater conduits when sediment-laden meltwaters are discharged into a standing body of water. The geometry of the resulting deposit is fan- or lobe-shaped. Several of these lobes may be joined together to form a larger, continuous sedimentary body. Internally, subaqueous fans consist of stratified sands and gravels which may exhibit wide variations in grain size distribution. As these features were deposited under glacial lake waters, silt and clay which settled out of these lakes may be associated in varying amounts with these deposits. The variability of the sediments and presence of fines are the main extractive problems associated with these deposits.

Alluvium (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or

semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 6 m thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular subbase aggregate.

GLACIAL DEPOSITS

End Moraines (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well-developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consist of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

Appendix D – Geology of Bedrock Deposits

The purpose of this appendix is to familiarize the reader with the general bedrock geology of southern Ontario (Figure D1) and, where known, the potential uses of the various bedrock formations. The reader is cautioned against using this information for more specific purposes. The stratigraphic chart (Figure D2) is intended only to illustrate the stratigraphic sequences in particular geographic areas and should not be used as a regional correlation table.

The following description is arranged in ascending stratigraphic order, on a group and formation basis. Precambrian rocks are not discussed. Additional stratigraphic information is included for some formations where necessary. The publications and maps of the Ontario Geological Survey (e.g. Johnson et al. 1992) and the Geological Survey of Canada should be referred to for more detailed information. The composition, thickness and uses of the formations are discussed. If a formation may be suitable for use as aggregate and aggregate suitability test data are available, the data have been included in the form of ranges. The following short forms have been used in presenting this data: PSV = Polished Stone Value, AAV = Aggregate Abrasion Value, $MgSO_4$ = Magnesium Sulphate Soundness Test (loss in percent), LA = Los Angeles Abrasion and Impact Test (loss in percent), Absn = Absorption (percent), BRD = Bulk Relative Density, PN (Asphalt & Concrete) = Petrographic Number for Asphalt and Concrete use. The ranges are intended as a guide only and care should be exercised in extrapolating the information to specific situations. Aggregate suitability test data has been provided by the Ontario Ministry of Transportation.

Covey Hill Formation (Cambrian)

STRATIGRAPHY: lower formation of the Potsdam Group. COMPOSITION: interbedded non-calcareous feldspathic conglomerate and sandstone. THICKNESS: 0 to 14 m. USES: has been quarried for aggregate in South Burgess Township, Leeds County.

Nepean Formation (Cambro-Ordovician)

STRATIGRAPHY: part of the Potsdam Group. COMPOSITION: thin- to massive-bedded quartz sandstone with some conglomerate interbeds and rare shaly partings. THICKNESS: 0 to 30 m. USES: suitable as dimension stone; quarried at Philipsville and Forfar for silica sand; alkali-silica reactive in Portland cement concrete. AGGREGATE SUITABILITY TESTING: PSV = 54-68, AAV = 4-15, $MgSO_4$ = 9-32, LA = 44-90, Absn = 1.6-2.6, BRD = 2.38-2.50, PN (Asphalt & Concrete) = 130-140.

March Formation (Lower Ordovician)

STRATIGRAPHY: lower formation of the Beekmantown Group. COMPOSITION: interbedded quartz sandstone, dolomitic quartz sandstone, sandy dolostone and dolostone. THICKNESS: 6 to 64 m. USES: quarried extensively for aggregate in area of subcrop and outcrop; alkali-silica reactive in Portland cement concrete; lower part of formation is an excellent source of skid-resistant aggregate. Suitable for use as facing stone and paving stone. AGGREGATE SUITABILITY TESTING: PSV = 55-60, AAV = 4-6, $MgSO_4$ = 1-17, LA = 15-38, Absn = 0.5-0.9, BRD = 2.61-2.65, PN (Asphalt & Concrete) = 110-150.

Oxford Formation (Lower Ordovician)

STRATIGRAPHY: upper formation of the Beekmantown Group. COMPOSITION: thin- to thick-bedded, microcrystalline to medium-crystalline, grey dolostone with thin shaly interbeds. THICKNESS: 61 to 102 m. USES: quarried in the Brockville and Smith Falls areas and south of Ottawa for use as aggregate. AGGREGATE SUITABILITY TESTING: PSV = 47-48, AAV = 7-8, $MgSO_4$ = 1-4, LA = 18-23, Absn = 0.7-0.9, BRD = 2.74-2.78, PN (Asphalt & Concrete) = 105-120.

Rockcliffe Formation (Middle Ordovician)

STRATIGRAPHY: divided into lower member and upper (St. Martin) member. COMPOSITION: interbedded quartz sandstone and shale; interbedded shaly bioclastic limestone and shale predominating in upper member to the east. THICKNESS: 0 to 125 m. USES: upper member has been quarried east of Ottawa for aggregate; lower member has been used as crushed stone; some high purity limestone beds in upper member may be suitable for use as fluxing stone and in lime production. AGGREGATE SUITABILITY TESTING: PSV = 58-63, AAV = 10-11, $MgSO_4$ = 12-40, LA = 25-28, Absn = 1.8-1.9, BRD = 2.55-2.62, PN (Asphalt & Concrete) = 122-440.

Shadow Lake Formation (Middle Ordovician)

STRATIGRAPHY: eastern Ontario - the basal unit of the Ottawa Group; central Ontario - overlain by the Simcoe Group. COMPOSITION: in eastern Ontario - silty and sandy dolostone with shale partings and minor interbeds of sandstone; in central Ontario - conglomerates, sandstones, and shales. THICKNESS: eastern Ontario - 2 to 3 m; central Ontario - 0 to 12 m. USES: potential source of decorative stone; very limited value as aggregate source.

Gull River Formation (Middle Ordovician)

STRATIGRAPHY: part of the Simcoe Group (central Ontario) and Ottawa Group (eastern Ontario). In eastern Ontario the formation is subdivided into upper and lower members; in central Ontario it is presently subdivided into upper, middle and lower members. COMPOSITION: in central and eastern Ontario the lower member consists of alternating units of limestone, dolomitic limestone and dolostone, the upper member consists of thin-bedded limestones with thin shale partings; west of Lake Simcoe the lower member is thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone whereas the upper and middle members are dense microcrystalline limestones with argillaceous dolostone interbeds. THICKNESS: 7.5 to 136 m. USES: quarried in the Lake Simcoe, Kingston, Ottawa and Cornwall areas for crushed stone. Rock from certain layers in eastern and central Ontario has proven to be alkali-reactive when used in Portland cement concrete (alkali-carbonate reaction). AGGREGATE SUITABILITY TESTING: PSV = 41-49, AAV = 8-12, $MgSO_4$ = 3-13, LA = 18-28, Absn = 0.3-0.9, BRD = 2.68-2.73, PN (Asphalt & Concrete) = 100-153.

Bobcaygeon Formation (Middle Ordovician)

STRATIGRAPHY: part of the Simcoe Group (central Ontario) and the Ottawa Group (eastern Ontario), subdivided into upper, middle and lower members; members in eastern and central Ontario are approximately equivalent. COMPOSITION: homogeneous, massive to thin-bedded fine-crystalline limestone with numerous shaly partings in the middle member. THICKNESS: 7 to 87 m. USES: quarried at Brechin, Marysville, and in the Ottawa area for crushed stone. Generally suitable for use as granular base course aggregate. Rock from certain layers has been found to be alkali-reactive when used in Portland cement concrete (alkali-silica reaction). AGGREGATE SUITABILITY TESTING: PSV = 47-51, AAV = 14-23, $MgSO_4$ = 1-40, LA = 18-32, Absn = 0.3-2.4, BRD = 2.5-2.69, PN (Asphalt & Concrete) = 100-320.

Verulam Formation (Middle Ordovician)

STRATIGRAPHY: part of Simcoe and Ottawa Groups. COMPOSITION: fossiliferous, pure to argillaceous limestone interbedded with calcareous shale. THICKNESS: 32 to 65 m. USES: quarried at Picton and Bath for use in cement manufacture. Quarried for aggregate in Ramara Township, Simcoe County and in the Belleville–Kingston area. May be unsuitable for use as aggregate in some areas because of its high shale content. AGGREGATE SUITABILITY TESTING: PSV = 43-44, AAV = 9-13, $MgSO_4$ = 4-45, LA = 22-29, Absn = 0.4-2.1, BRD = 2.59-2.70, PN (Asphalt & Concrete) = 120-255.

Lindsay Formation (Middle Upper Ordovician)

STRATIGRAPHY: part of Simcoe and Ottawa Groups; in eastern Ontario is divisible into an unnamed lower member and the Eastview Member; in central Ontario is divisible into the Collingwood Member (equivalent to portions of the Eastview Member) and a lower member. COMPOSITION: eastern Ontario - the lower member is interbedded, very fine- to coarse-crystalline limestone with undulating shale partings and interbeds of dark grey calcareous shale, whereas the Eastview Member is an interbedded dark grey to dark brown calcareous shale and very fine- to fine-crystalline, petroliferous limestone; central Ontario – Collingwood Member is a black, calcareous shale whereas the lower member is a very fine- to coarse-crystalline, thin-bedded limestone with very thin, undulating shale partings. THICKNESS: 25 to 67 m. USES: eastern Ontario - lower member is used extensively for aggregate production; central Ontario - quarried at Picton, Ogden Point and Bowmanville for cement. May be suitable or unsuitable for use as concrete and asphalt aggregate. AGGREGATE SUITABILITY TESTING: $MgSO_4$ = 2-47, LA = 20-28, Absn = 0.4-1.3, BRD = 2.64-2.70, PN (Asphalt & Concrete) = 110-215.

Blue Mountain and Billings Formations (Upper Ordovician)

STRATIGRAPHY: central Ontario – Blue Mountain Formation includes the upper and middle members of the former Whitby Formation; eastern Ontario – Billings Formation is equivalent to part of the Blue Mountain Formation. COMPOSITION: Blue Mountain Formation - blue-grey, noncalcareous shales; Billings Formation - dark grey to black, noncalcareous to slightly calcareous, pyritiferous shale with dark grey limestone laminae and grey siltstone interbeds. THICKNESS: Blue Mountain Formation - 43 to 61 m; Billings Formation - 0 to 62 m. USES: Billings Formation may be a suitable source for structural clay products and expanded aggregate; Blue Mountain Formation may be suitable for structural clay products.

Georgian Bay and Carlsbad Formations (Upper Ordovician)

COMPOSITION: central Ontario – Georgian Bay Formation composed of interbedded limestone and shale; eastern Ontario – Carlsbad Formation composed of interbedded shale, siltstone and bioclastic limestone. THICKNESS: Georgian Bay Formation - 91 to 170 m. Carlsbad Formation - 0 to 186 m. USES: Georgian Bay Formation - used by several producers in Metropolitan Toronto area to produce brick and structural tile, as well as for making Portland cement; at Streetsville, expanded shale was used in the past to produce lightweight ag-

gregate. Carlsbad Formation - used as a source material for brick and tile manufacturing, has potential as a lightweight expanded aggregate.

Queenston Formation (Upper Ordovician)

COMPOSITION: red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. THICKNESS: 45 to 335 m. USES: There are several large quarries developed in the Queenston Formation in the Toronto–Hamilton region and one at Russell, near Ottawa. All extract shale for brick manufacturing. The Queenston Formation is the most important source material for brick manufacture in Ontario.

Whirlpool Formation (Lower Silurian)

STRATIGRAPHY: lower formation in the Cataract Group in the Niagara Peninsula and the Niagara Escarpment as far north as Duntroon. COMPOSITION: massive, medium- to coarse-grained, argillaceous white to light grey quartz sandstone with thin grey shale partings. THICKNESS: 0 - 8 m. USES: building stone, flagstone.

Manitoulin Formation (Lower Silurian)

STRATIGRAPHY: part of the Cataract Group, occurs north of Stoney Creek. COMPOSITION: thin-bedded, blue-grey to buff-brown dolomitic limestones and dolostones. THICKNESS: 0 to 25 m. USES: extracted for crushed stone in St. Vincent and Sarawak townships, Grey County, and for decorative stone on Manitoulin Island.

Cabot Head Formation (Lower Silurian)

STRATIGRAPHY: part of the Cataract Group, occurs in subsurface throughout southwestern Ontario and outcrops along the length of the Niagara Escarpment. COMPOSITION: green, grey and red shales. THICKNESS: 10 to 39 m. USES: potential source of coated lightweight aggregate and raw material for use in manufacture of brick and tile. Extraction limited by lack of suitable exposures.

Grimsby Formation (Lower Silurian)

STRATIGRAPHY: upper formation of the Cataract Group, is identified on the Niagara Peninsula as far north as Clappison's Corners. COMPOSITION: interbedded sandstone and shale, mostly red. THICKNESS: 0 to 15 m. USES: no present uses.

Thorold Formation (Middle Silurian)

STRATIGRAPHY: lower formation in the Clinton Group on the Niagara Peninsula. COMPOSITION: thick-bedded quartz sandstone. THICKNESS: 2 - 3 m. USES: no present uses.

Neagha Formation (Middle Silurian)

STRATIGRAPHY: part of the Clinton Group on the Niagara Peninsula. COMPOSITION: dark-grey to green shale with minor interbedded limestone. THICKNESS: 0 to 2 m. USES: no present uses.

Dyer Bay Formation (Middle Silurian)

STRATIGRAPHY: on Manitoulin Island and northernmost Bruce Peninsula. COMPOSITION: highly fossiliferous, impure dolostone. THICKNESS: 0 to 7.5 m. USES: no present uses.

Wingfield Formation (Middle Silurian)

STRATIGRAPHY: on Manitoulin Island and northernmost Bruce Peninsula. COMPOSITION: olive green to grey shale with dolostone interbeds. THICKNESS: 0 to 15 m. USES: no present uses.

St. Edmund Formation (Middle Silurian)

STRATIGRAPHY: occurs on Manitoulin Island and northernmost Bruce Peninsula, upper portion previously termed the Mindemoya Formation. COMPOSITION: pale grey to buff-brown, micro- to medium-crystalline, thin- to medium-bedded dolostone. THICKNESS: 0 to 25 m. USES: quarried for fill and crushed stone on Manitoulin Island. AGGREGATE SUITABILITY TESTING: $MgSO_4$ = 1-2, LA = 19-21, Absn = 0.6-0.7, BRD = 2.78-2.79, PN (Asphalt & Concrete) = 105.

Fossil Hill and Reynales Formations (Middle Silurian)

STRATIGRAPHY: Fossil Hill Formation occurs in the northern part of the Niagara Escarpment and is approximately equivalent in part to the Reynales Formation which occurs on the Niagara Peninsula and the Escarpment as far north as the Forks of the Credit. COMPOSITION: Fossil Hill Formation - fine- to coarse-crystalline dolostone with high silica content; Reynales Formation - thin- to thick-bedded shaly dolostone and dolomitic limestone. THICKNESS: Fossil Hill Formation 6 to 26 m; Reynales Formation 0 to 3 m. USES: both formations quarried for aggregate with overlying Amabel and Lockport Formations. AGGREGATE SUITABILITY TESTING: (Fossil Hill Formation on Manitoulin Island) $MgSO_4$ = 41, LA = 29, Absn = 4.1, BRD = 2.45, PN (Asphalt & Concrete) = 370.

Irondequoit Formation (Middle Silurian)

STRATIGRAPHY: part of Clinton Group on the Niagara Peninsula south of Waterdown. COMPOSITION:

massive, coarse-crystalline crinoidal limestone. THICKNESS: 0 to 2 m. USES: not utilized extensively.

Rochester Formation (Middle Silurian)

STRATIGRAPHY: part of Clinton Group along the Niagara Peninsula. COMPOSITION: black to dark grey calcareous shale with numerous limestone lenses. THICKNESS: 5 to 24 m. USES: not utilized extensively. AGGREGATE SUITABILITY TESTING: PSV = 69, AAV = 17, $MgSO_4$ = 95, LA = 19, Asbn = 2.2, BRD = 2.67, PN (Asphalt & Concrete) = 400.

Decew Formation (Middle Silurian)

STRATIGRAPHY: part of Clinton Group south of Waterdown along the Niagara Peninsula. COMPOSITION: sandy to shaly dolomitic limestone and dolostone. THICKNESS: 0 to 5 m. USES: too shaley for high quality uses, but is quarried along with Lockport Formation in places. AGGREGATE SUITABILITY TESTING: PSV = 67, AAV = 15, $MgSO_4$ = 55, LA = 21, Absn = 2.2, BRD = 2.66, PN (Asphalt & Concrete) = 255.

Lockport and Amabel Formations (Middle Silurian)

STRATIGRAPHY: Lockport Formation occurs from Waterdown to Niagara Falls, subdivided into 3 formal members: Gasport, Goat Island and Eramosa Members, and an informal member (the "Vinemount shale beds"); the approximately equivalent Amabel Formation, found from Waterdown to Cockburn Island, has been subdivided into Lions Head, Wiarton/Colpoy Bay and Eramosa Members. On the Bruce Peninsula and in the subsurface of southwestern Ontario the Eramosa Member is considered to be part of the overlying Guelph Formation. COMPOSITION: Lockport Formation is thin- to massive-bedded, fine- to medium-crystalline dolostone; Amabel Formation is thin- to massive-bedded, fine- to medium-crystalline dolostone with reef facies developed near Georgetown and on the Bruce Peninsula. The Eramosa Member is thin bedded and bituminous. THICKNESS: (Lockport/Amabel) 3 to 40 m. USES: both formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. AGGREGATE SUITABILITY TESTING: PSV = 36-49, AAV = 10-17, $MgSO_4$ = 2-6, LA = 25-32, Absn = 0.4-1.54, BRD = 2.61-2.81, PN (Asphalt & Concrete) = 100-105.

Guelph Formation (Middle Silurian)

STRATIGRAPHY: exposed south and west of the Niagara Escarpment from the Niagara River to the tip of the Bruce Peninsula, mostly present in the subsurface of southwestern Ontario. COMPOSITION: fine- to medium-crystalline, medium- to thick-bedded, porous dolostone, characterized in places by extensive vuggy, porous reefal facies of high chemical purity. THICKNESS: 4 to 100 m. USES: some areas appear soft and unsuitable for use in the production of load-bearing aggregate. This unit requires additional testing to fully establish its aggregate suitability. Main use is for dolomitic lime for cement manufacture. Quarried near Hamilton and Guelph.

Salina Formation (Upper Silurian)

STRATIGRAPHY: present in the subsurface of southwestern Ontario; only rarely exposed at surface. COMPOSITION: grey and maroon shale, brown dolostone and, in places, salt, anhydrite and gypsum; consists predominantly of evaporitic-rich material with up to eight units identifiable. THICKNESS: 113 to 330 m. USES: gypsum mines at Hagersville, Caledonia and Drumbo. Salt is mined at Goderich and Windsor and is produced from brine wells at Amherstburg, Windsor and Sarnia.

Bertie and Bass Islands Formations (Upper Silurian)

STRATIGRAPHY: Bertie Formation found in southern Niagara Peninsula; Bass Islands Formation, the Michigan Basin equivalent of the Bertie Formation, rarely outcrops in Ontario but is present in the subsurface in southwestern Ontario; Bertie Formation represented by Oatka, Falkirk, Scajaquanda, Williamsville and Akron Members. COMPOSITION: medium- to massive-bedded, micro-crystalline, brown dolostone with shaly partings. THICKNESS: 14 to 28 m. USES: quarried for crushed stone on the Niagara Peninsula; shaly intervals are unsuitable for use as high specification aggregate because of low freeze-thaw durability. Has also been extracted for lime. AGGREGATE SUITABILITY TESTING: PSV = 46-49, AAV = 8-11, $MgSO_4$ = 4-19, LA = 14-23, Absn = 0.8-2.8, BRD = 2.61-2.78, PN (Asphalt & Concrete) = 102-120.

Oriskany Formation (Lower Devonian)

STRATIGRAPHY: basal Devonian clastic unit, found in Niagara Peninsula. COMPOSITION: thick- to massive-bedded, coarse-grained, grey-yellow sandstone. THICKNESS: 0 to 5 m. USES: has been quarried for silica sand, building stone and armour stone. May be acceptable for use as rip rap, and well-cemented varieties may be acceptable for some asphaltic products. AGGREGATE SUITABILITY TESTING: (of a well-cemented variety of the formation) PSV = 64, AAV = 6, $MgSO_4$ = 2, LA = 29, Absn = 1.2-1.3, BRD = 2.55, PN (Asphalt & Concrete) = 107.

Bois Blanc Formation (Lower Devonian)

STRATIGRAPHY: Springvale Sandstone Member forms the lower portion of formation. COMPOSITION: a cherty limestone with shale partings and minor interbedded dolostones; Springvale Sandstone Member is a medium- to coarse-grained, green glauconitic sand-

stone with interbeds of limestone, dolostone and brown chert. THICKNESS: 3 to 40 m. USES: quarried at Hagersville, Cayuga and Port Colborne for crushed stone. Material generally unsuitable for concrete aggregate because of high chert content. AGGREGATE SUITABILITY TESTING: PSV = 48-53, AAV = 3-7, $MgSO_4$ = 3-18, LA = 15-22, Absn = 1.3-2.8, BRD = 2.50-2.70, PN (Asphalt & Concrete) = 102-290.

Onondaga Formation (Lower - Middle Devonian)

STRATIGRAPHY: correlated to part of the Detroit River Group; occurs on the Niagara Peninsula from Simcoe to Niagara Falls; contains the Edgecliff, Clarence and Moorehouse Members. COMPOSITION: medium-bedded, fine- to coarse-grained, dark grey-brown or purplish-brown, variably cherty limestone. THICKNESS: 8 to 25 m. USES: quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for use as concrete aggregate and asphaltic concrete. Has been used as a raw material in cement manufacture. AGGREGATE SUITABILITY TESTING: (Clarence and Edgecliff Members) $MgSO_4$ = 1-6, LA = 16.8-22.4, Absn = 0.5-1.1, PN (Asphalt & Concrete) = 190-276.

Amherstburg Formation (Lower - Middle Devonian)

STRATIGRAPHY: part of Detroit River Group; correlated to Onondaga Formation in Niagara Peninsula; contains Sylvania Sandstone Member and Formosa Reef Limestone. COMPOSITION: bituminous, bioclastic, stromatoporoid-rich limestone with grey chert nodules; Formosa Reef Limestone - high purity (calcium-rich) limestone; Sylvania Sandstone Member - quartz sandstone. THICKNESS: 0 to 60 m; Formosa Reef Limestone - up to 26 m. USES: cement manufacture, agricultural lime, aggregate. AGGREGATE SUITABILITY TESTING: PSV = 57, AAV = 19, $MgSO_4$ = 9-35, LA = 26-52, Absn = 1.1-6.4, BRD = 2.35-2.62, PN (Asphalt & Concrete) = 105-300.

Lucas Formation (Middle Devonian)

STRATIGRAPHY: part of the Detroit River Group in southwestern Ontario; includes the Anderdon Member which, in the Woodstock–Beachville area, may constitute the bulk of the formation. COMPOSITION: light brown or grey-brown dolostone with bituminus laminations and minor chert; Anderdon Member consists of very high purity (calcium-rich) limestone and locally, sandy limestone. THICKNESS: 40 to 75 m. USES: most important source of high-purity limestone in Ontario. Used as calcium lime for metallurgical flux and for the manufacture of chemicals. Rock of lower purity is used for cement manufacture, agricultural lime and aggregate. Anderdon Member is quarried at Amherstburg for crushed stone. AGGREGATE SUITABILITY TESTING: PSV = 46-47, AAV = 15-16, $MgSO_4$ = 2-60, LA = 22-47, Absn = 1.1-6.5, BRD = 2.35-2.40, PN (Asphalt & Concrete) = 110-160.

Dundee Formation (Middle Devonian)

STRATIGRAPHY: few natural outcrops, largely in the subsurface of southwestern Ontario. COMPOSITION: fine- to medium-crystalline, brownish-grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. THICKNESS: 15 to 45 m. USES: quarried near Port Dover and on Pelee Island for crushed stone. Used at St. Marys as a raw material for Portland cement. AGGREGATE SUITABILITY TESTING: $MgSO_4$ = 1-28, LA = 22-46, Absn = 0.6-6.8, PN (Asphalt & Concrete) = 125-320.

Marcellus Formation (Middle Devonian)

STRATIGRAPHY: subsurface unit, mostly found below Lake Erie and extending into the eastern USA, pinches out in the Port Stanley area. COMPOSITION: black, bituminous shales. THICKNESS: 0 to 12 m. USES: no present uses.

Bell Formation (Middle Devonian)

STRATIGRAPHY: lowest formation of the Hamilton Group, no outcrop in Ontario. COMPOSITION: soft, blue and grey calcareous shale. THICKNESS: 0 to 14.5 m. USES: no present uses.

Rockport Quarry Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group; no outcrop in Ontario. COMPOSITION: grey-brown, very fine-grained limestone with occasional shale layers. THICKNESS: 0 to 6 m. USES: no present uses.

Arkona Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group. COMPOSITION: blue-grey, plastic, clay shale with occasional thin and laterally discontinuous limestone lenses. THICKNESS: 5 to 37 m. USES: has been extracted at Thedford and near Arkona for the production of drainage tile.

Hungry Hollow Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group. COMPOSITION: grey crinoidal limestone and soft, fossiliferous calcareous shale. THICKNESS: 0 to 2 m. USES: suitable for some crushed stone and fill with selective quarrying.

Widder Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group. COMPOSITION: mainly soft, grey, fossiliferous calcareous

shale interbedded with blue-grey, fine-grained fossiliferous limestone. THICKNESS: 0 to 21 m. USES: no present uses.

Ipperwash Formation (Middle Devonian)

STRATIGRAPHY: upper formation of the Hamilton Group; very limited distribution. COMPOSITION: medium- to coarse grained, grey-brown, bioclastic limestone. THICKNESS: 2 to 14 m. USES: no present uses.

Kettle Point Formation (Upper Devonian)

STRATIGRAPHY: occurs in a northwest-trending band between Sarnia and Erieau; small part overlain by Port Lambton Group rocks in extreme northwest. COMPOSITION: black, highly fissile, organic-rich shale with minor interbeds of grey-green silty shale. THICKNESS: 0 to 75 m. USES: possible source of material for use as sintered lightweight aggregate or fill.

Bedford Formation (Upper Devonian or Mississippian)

STRATIGRAPHY: lower formation of the Port Lambton Group. COMPOSITION: soft, grey shale. THICKNESS: 0 to 30 m. USES: no present uses.

Berea Formation (Upper Devonian or Mississippian)

STRATIGRAPHY: middle formation of the Port Lambton Group; not known to occur at surface in Ontario. COMPOSITION: grey, fine- to medium-grained sandstone, often dolomitic and interbedded with grey shale and siltstone. THICKNESS: 0 to 60 m. USES: no present uses.

Sunbury Formation (Upper Devonian or Mississippian)

STRATIGRAPHY: upper formation of the Port Lambton Group; not known to occur at surface in Ontario. COMPOSITION: black shale. THICKNESS: 0 to 20 m. USES: no present uses.

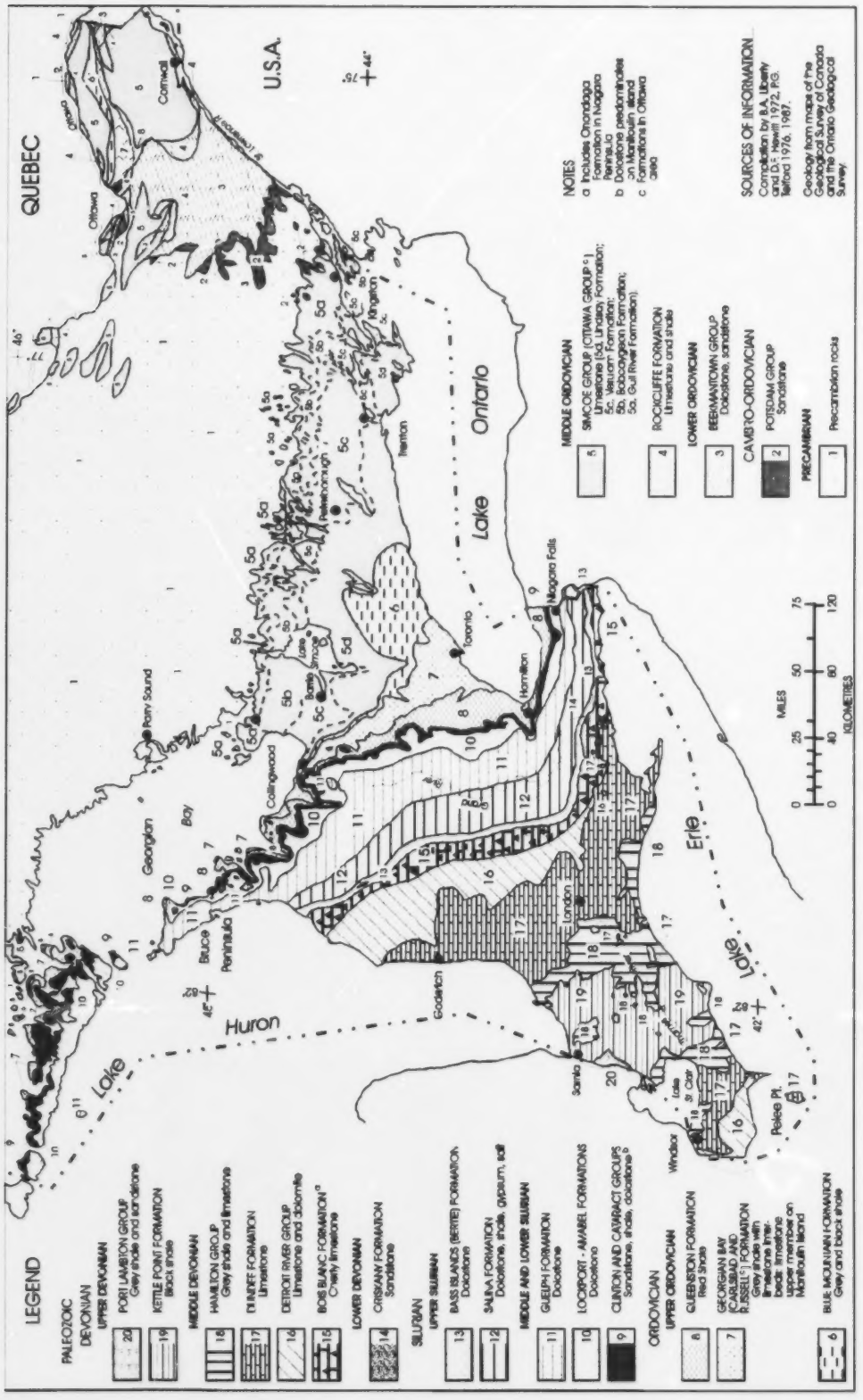
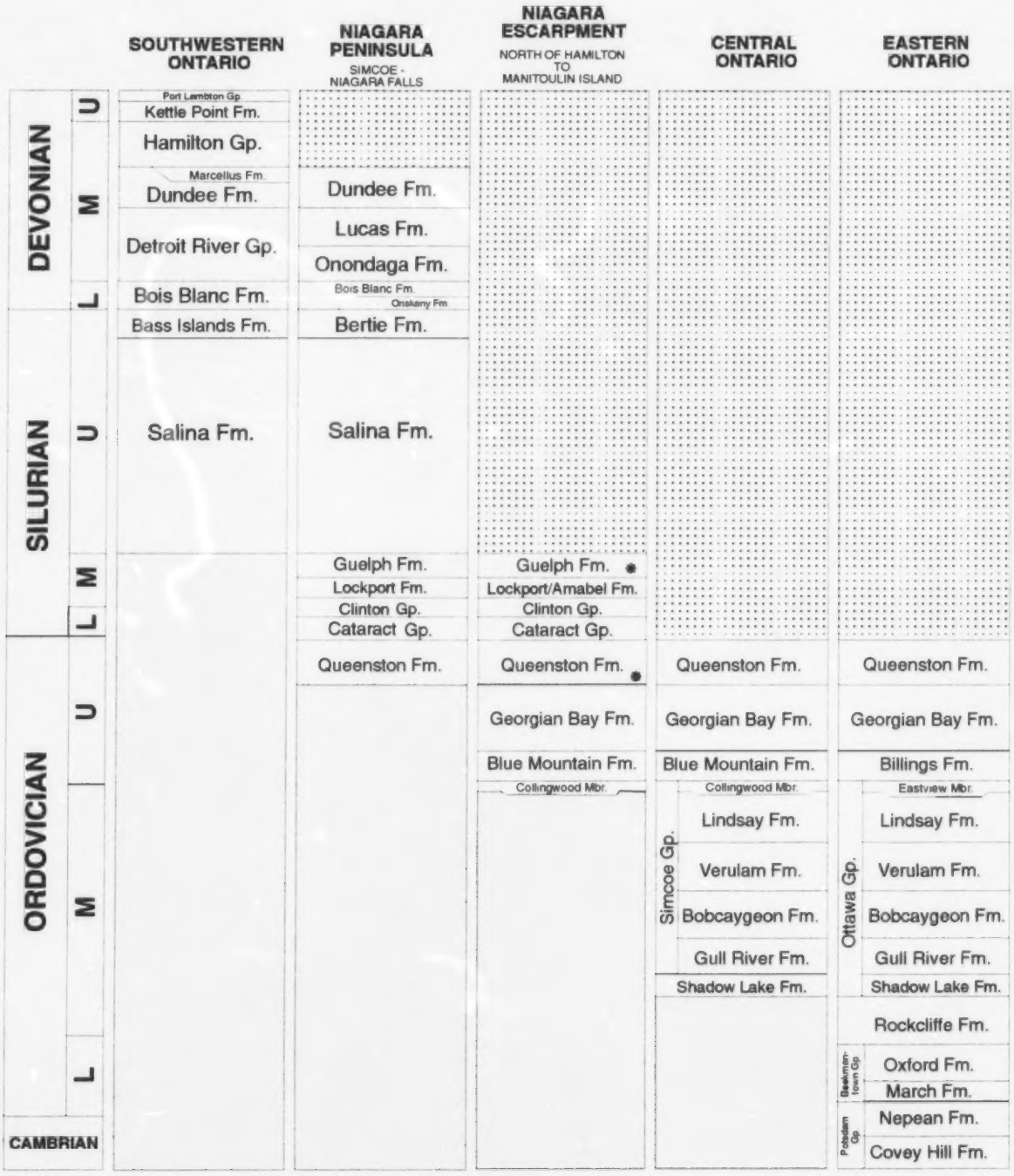


Figure D1. Bedrock geology of southern Ontario.



Gp.= Group, Fm. = Formation, Mbr. = Member

● Does not occur on Manitoulin Island

Figure D2. Exposed Paleozoic stratigraphic sequences in southern Ontario (*adapted from*: Bezys, R.K. and Johnson, M.D. 1988. The geology of the Paleozoic formations utilized by the limestone industry of Ontario; The Can. Mining and Metallurgical Bulletin, v.81, no. 912, p.49-58.)

Appendix E – Aggregate Quality Test Specifications

Six types of aggregate quality tests are often performed by the Ontario Ministry of Transportation on sampled material. A description and the specification limits for each test are included in this appendix. Although a specific sample meets or does not meet the specification limits for a certain product, it may or may not be acceptable for that use based on field performance. Additional quality tests other than the six tests listed in this appendix can be used to determine the suitability of an aggregate. The tests are performed by the Ontario Ministry of Transportation.

Absorption Capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate. This test is conducted in conjunction with the determination of the sample's relative density.

Los Angeles Abrasion and Impact Test: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported and placed. Values less than about 35% indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45% indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

Magnesium Sulphate Soundness Test: This test is designed to simulate the action of freezing and thawing on aggregate. Those aggregates which are susceptible will usually break down and give high losses in this test. Values greater than about 12 to 15% indicate potential problems for concrete and asphalt coarse aggregate.

Micro-Deval Abrasion Test: The Micro-Deval Abrasion test is an accurate measure of the amount of hard, durable materials in sand-sized particles. This abrasion test is quick, cheap and more precise than the fine aggregate Magnesium Sulphate Soundness test that suffers from a wide multilaboratory variation. The maximum loss for HL 1/HL 3 is 20%, for HL 2 and HL 4/HL 8 it is 25% and for structural and pavement concrete it is 20%. It is anticipated that this test will replace the fine aggregate Magnesium Sulphate Soundness test.

Mortar Bar Accelerated Expansion Test: This is a rapid test for detecting alkali-silica reactive aggregates. It involves the crushing of the aggregate and the creation of standard mortar bars. For coarse and fine aggregates, suggested expansion limits of 0.10 to 0.15% are indicated for innocuous aggregates, greater than 0.10% but less than 0.20% indicates that it is unknown whether a potentially deleterious reaction will occur, and greater than 0.20% indicates that the aggregate is probably reactive and should not be used for Portland cement concrete. If the expansion limit exceeds 0.10% for coarse and fine aggregates, it is recommended that supplementary information be developed to confirm that the expansion is actually because of alkali-reactivity. If confirmed deleteriously reactive, the material should not be used for Portland cement concrete unless corrective measures are undertaken such as the use of low- or reduced-alkali cement.

Petrographic Examination: Individual aggregate particles in a sample are divided into categories good, fair, poor and deleterious, based on their rock type (petrography) and knowledge of past field performance. A petrographic number (PN) is calculated. The higher the PN, the lower the quality of the aggregate.

Table E1. Selected quality requirements for major aggregate products.

TYPE OF TEST						
	COARSE AGGREGATE				FINE AGGREGATE	
TYPE OF MATERIAL	Petrographic Number Maximum	Magnesium Sulphate Soundness Maximum % Loss	Absorption Maximum %	Los Angeles Abrasion Maximum % Loss	Micro-Deval Abrasion Maximum % Loss	Magnesium Sulphate Soundness Maximum % Loss
Granular A	200	-	-	60		-
Granular B Type 1	250*	-	-	-		-
Granular B Type 2	250	-	-	60		-
Granular M	200	-	-	60		-
Granular S	200	-	-	-		-
Select Subgrade Material	250	-	-	-		-
Open Graded Drainage Layer (1)	160	15	2.0	35		-
Hot Mix-HL 1, DFC, OFC	See OPSS 1149 and Special Provision No. 313S10					
Surface Treatment Class 1	135	12	1.75	35		-
Surface Treatment Class 2	160	15	-	35		-
Surface Treatment Class 3	160	12	2.0	35		-
Surface Treatment Class 4	-	-	-	-		20
Surface Treatment Class 5	135	12	1.75	35		-
Hot Mix - HL 1	100	5	1.0	15	20	16
Hot Mix - HL 2	-	-	-	-	25	20
Hot Mix - HL 3	135	12	1.75	35	20	16
Hot Mix - HL 4	160	12	2.0	35	20	20
Hot Mix - HL 8	160	15	2.0	35	25	20
Structural Concrete, Sidewalk, Curb, Gutter and Base	140	12	2.0	50	20	16
Pavement Concrete	125	12	2.0	35	20	16

*** requirement waived if the material has more than 80% passing the 4.75 mm sieve**
(1) Hot mix and concrete petrographic number applies
(Ontario Provincial Standard Specifications OPSS 304, OPSS 1002, OPSS 1003, OPSS 1010 and OPSS 1149)

Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.